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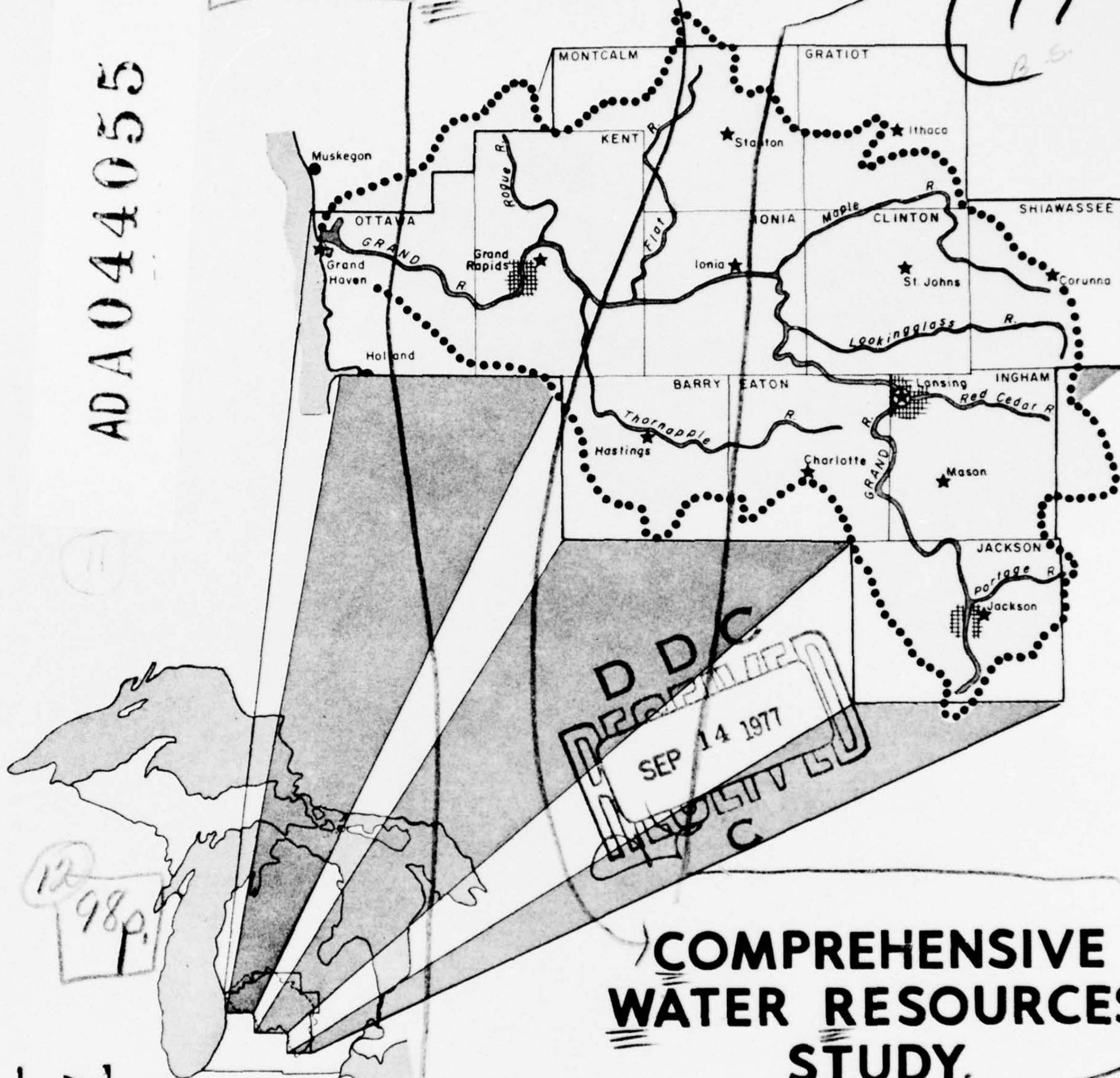
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

GRAND RIVER BASIN
MICHIGAN



COMPREHENSIVE WATER RESOURCES STUDY

VOLUME V

APPENDIX G - WATER SUPPLY AND STREAM QUALITY—HEALTH GUIDELINES

Prepared Under Supervision of the
GRAND RIVER BASIN COORDINATING COMMITTEE
Chairmanship: U. S. Army Engineer District, Detroit

May 1970

APPENDIX G

WATER SUPPLY AND STREAM QUALITY

COMPREHENSIVE WATER RESOURCES STUDY

OF THE

GRAND RIVER BASIN, MICHIGAN

April 1970

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes Region

Lake Michigan Basin Office, Chicago, Illinois

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SUMMARY

Background

Appendix G, "Water Supply and Stream Water Quality" has been prepared pursuant to a request by the U. S. Army Corps of Engineers in a letter dated May 22, 1963. Appendix G is one of several similar documents to be prepared by a variety of agencies who are participating in a "Comprehensive Planning Study of the Grand River Basin, Michigan." The study, under the chairmanship of the U. S. Army Corps of Engineers District, Detroit, Michigan deals with the best use of the water and related land resources of the Grand River Basin. The information and interpretations summarized below are based on data collected by the GLIRB Project during its water quality studies of the Lake Michigan Basin (1962-1964). These studies have been supplemented by data obtained from other Federal agencies, the State of Michigan and local agencies.

Pollution in the Grand River

The waters of the Grand River are degraded in quality particularly below Jackson and Lansing, and at its mouth near Grand Haven. This degradation in quality is evidenced by low dissolved oxygen levels, and other biological, chemical, microbiological and physical parameters analyzed by both Federal and state pollution control agencies.

Pollution of the waters of the Grand River is further evidenced by the impairment of water uses. Partial body contact recreation is hazardous due to high coliform bacteria and fecal streptococcus bacterial densities below Jackson, Lansing, Grand Rapids and Grand Haven. The fishery of certain sectors of the Grand River is harmed by low dissolved oxygen levels and high stream temperatures. Esthetic enjoyment is impaired by the unsightly appearance of the Grand River at Jackson and certain other areas. The State of Michigan now requires continuous chlorination at all waste treatment plants.

Sources of Pollution

Municipal waste treatment plants of the Grand River Basin serve a population (1962) of 540,000. The combined effluents from these municipal treatment facilities discharge a total of 17,000 pounds of 5-day biochemical oxygen demand (BOD_5) daily to the waters of the Grand River Basin. These wastes are equivalent in oxygen-consuming power to the untreated wastes of over 100,000 persons. Other municipal waste sources include the overflows from combined sewer systems.

Industrial wastes discharging directly to the waters of the Grand River Basin put an additional 21,000 pounds of BOD_5 into the

streams daily. These wastes are equivalent in oxygen-consuming power to the untreated wastes of over 126,000 persons.

In addition to the organic waste load discharged from industries and municipalities, thermal discharges also have a significant bearing on water quality. For example, cooling water discharges from steam electric generating stations at Lansing produce adverse effects on desirable water uses.

Future Conditions

Growth projections indicate that the 1960 Grand River Basin population of 949,000 may increase more than two-fold by 2020. Industrial activity is expected to double by 1980 and to continue to expand in the decades that follow. Water demands and waste flows will increase at a more moderate pace due to increased water reuse and other efficiencies. These and other related factors indicate that the waste load received by all municipal sewerage systems in the Basin will increase to about 2,500,000 Population Equivalent (PE) by 2020. By comparison, the present estimated waste load received by all municipal sewerage systems of the Grand River Basin is approximately 540,000 PE.

Needed Water Quality Improvement Measures

A number of pollution control measures are presently needed in the Grand River Basin. These measures include secondary waste treatment for all major municipal waste sources and equivalent treatment for all significant industrial waste sources.

In addition, the recommendations of the Four-State Federal Enforcement Conference on the Pollution of Lake Michigan and its Tributaries require that communities provide at least 80% phosphorus removal on a statewide basis.

At some locations the foregoing measures alone will not be sufficient to achieve satisfactory water quality control. The study has identified two principal locations, the Jackson area and the Lansing area, where additional measures are required. A study of alternative measures reduces to the following: advanced waste treatment (beyond the basic degree specified above); augmentation of low flows in the stream receiving the treated wastewater effluents; piping of effluents to a more favorable location for discharge; or combinations of these.

Estimates have been made of the streamflows required to supplement basic wastewater treatment in maintaing established water quality standards, in the reaches of the Grand River at and immediately downstream from the cities of Jackson and Lansing. These estimated flows, for projected conditions of the years 1980 and 2020, are given in Table 5-6. The plan formulation appendix will present single purpose and multipurpose reservoir plans to provide all or part of this flow.

At Jackson, which is located near the headwaters of the river system, the required flows exceed the maximum physical supply of water obtainable from the river. Therefore, some form of advanced waste treatment will be required, and the city of Jackson is already taking steps to provide it. Should one or more multipurpose reservoirs in the Jackson area prove feasible, allocation of storage space for low-flow augmentation could be a valuable supplement to advanced waste treatment. Importation of water to the Jackson area is a possibility. However, unless water imported for low-flow augmentation is part of a total quantity brought in for several purposes, the costs of transporting water from one of the Great Lakes to Jackson for this purpose alone would be greater than the cost of providing a degree of treatment high enough to eliminate any need for supplemental streamflows.

At Lansing, where the Grand River is much larger than it is above Jackson, there is a more favorable opportunity for seeking least-cost combinations of wastewater treatment and low-flow augmentation.

A summary of alternatives for water quality control, and associated costs adjusted to a common time base for comparison, is given in Table 6-3.

The benefits of achieving and maintaining high quality water in the Grand River Basin will be widespread and far-reaching, even though not all of these benefits are susceptible of measurement in monetary values. Moreover, it is presumed that the procedures, including public hearings, through which Michigan's water quality standards were established, justify the premise that the people in the Basin consider achievement of these quality standards to be justified and worth what it will cost. On that premise and for purposes of benefit-cost analysis in any multipurpose reservoir projects being considered as part of the comprehensive plan for Grand River Basin, benefits of storage for water quality control are considered to be at least as much as the cost of the least costly alternative to such storage. As shown in Table 6-3, this is $330,000 per year at Jackson and $430,000 per year at Lansing.

Needed Water Supply Measures

It has been estimated that by 2020 Lansing, Michigan will require 118 mgd for municipal and industrial water supply. Lansing, Michigan ground water supply will be insufficient by about 28 mgd. This insufficiency can be made up by reservoir storage. An alternative to this storage would be to obtain water for this purpose from one of the Great Lakes.

SECTION 1

INTRODUCTION

Authorization

The Secretary of Health, Education, and Welfare was informed by the Secretary of the Army in a letter dated December 4, 1962 of the comprehensive water and related land resource investigations to be conducted in the Grand River Basin, Michigan. In response the Secretary of the Department of Health, Education and Welfare appointed a representative and an alternate to the Coordinating Committee of the Grand River Basin Comprehensive Study by a letter dated December 20, 1962. The District Engineer, U. S. Army Engineer District, Detroit, Michigan in a letter dated May 22, 1963 specifically requested the assistance of the Department of Health, Education, and Welfare. The Department was requested to study and to prepare a report concerning the water supply and wastewater disposal aspects in the Grand River Basin, Michigan.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et.seq.). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

Purpose and Scope

This report presents an action program of water pollution control geared to provide high quality waters in the Grand River Basin, Michigan through abatement of existing pollution, and to provide continuing control of pollution through actions scheduled in anticipation of future problems. This report and resulting program have been developed from information on present water quality, water uses and trends in water usage, present and anticipated future waste loads, the existing and projected population and economic growth, and other relevant facts.

The area (See Figure 1-1) within the scope of this appendix includes the Grand River and the entire watershed tributary to the Grand River. Water quality conditions in the adjacent water of Lake Michigan at the mouth of the Grand River are also considered, as well as the effects of Grand River discharge on Lake Michigan as a whole. Water quality problems of inland lakes are not covered.

Acknowledgments

The study was facilitated by the cooperation and assistance of the following Federal, state and local agencies. Their help is greatfully acknowledged.

1. U. S. Army Engineer District, Detroit, Michigan

2. U. S. Department of the Interior

   Bureau of Commercial Fisheries
   Bureau of Outdoor Recreation
   Bureau of Sport Fisheries and Wildlife
   Geological Survey

3. U. S. Department of Commerce

   Weather Bureau
   Office of Business Economics

4. U. S. Department of Agriculture

   Soil Conservation Service

5. State of Michigan

   Water Resources Commission, **Dept. of Natural Resources**
   Department of Public Health

6. Grand River Watershed Council

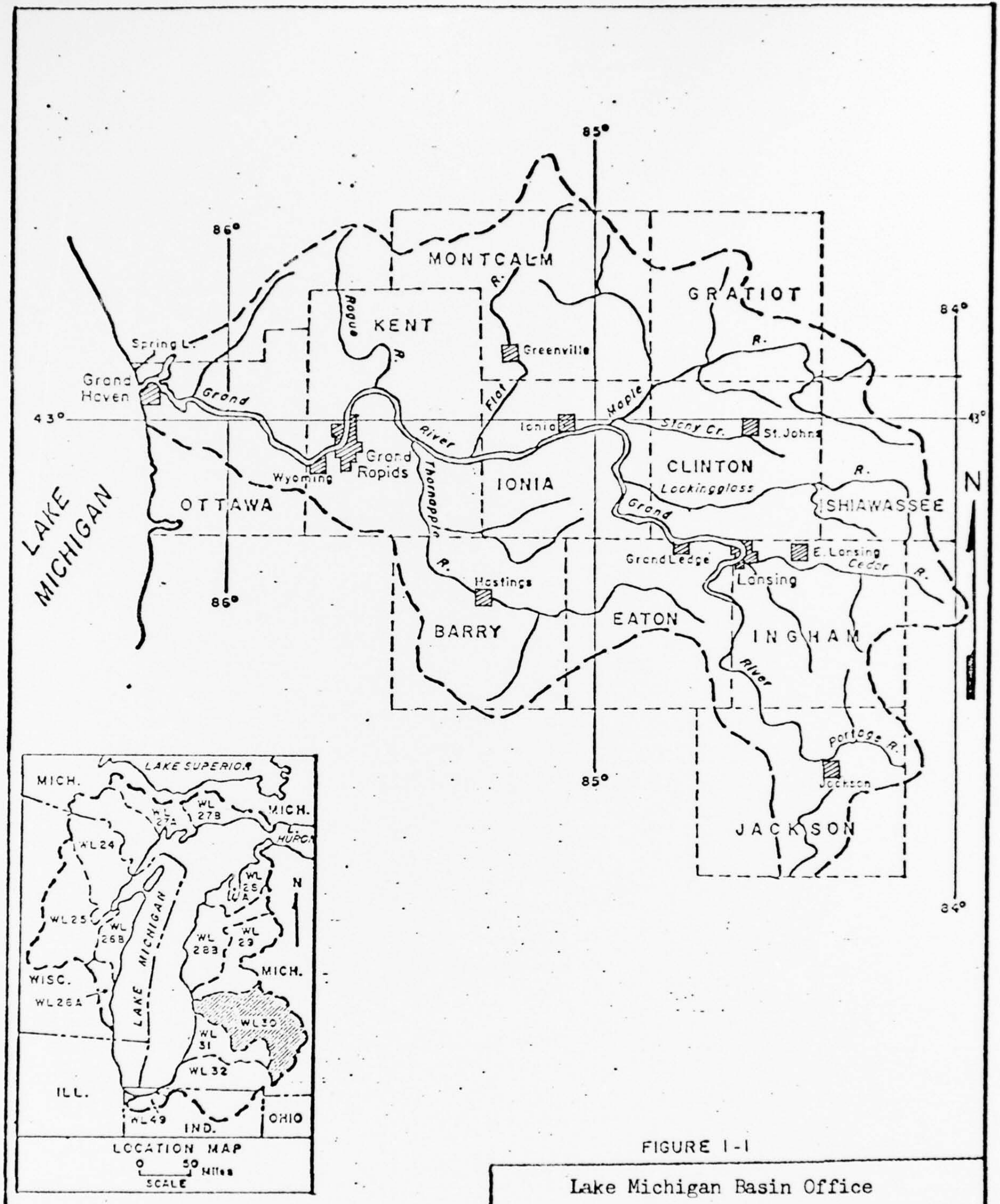

FIGURE 1-1

Lake Michigan Basin Office

GRAND RIVER BASIN - MICHIGAN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION CHICAGO, ILLINOIS

SECTION 2

DESCRIPTION OF AREA

Location

The Grand River Basin is located in the south-central part of the lower peninsula of Michigan. The Basin contains a drainage area of 5572 square miles. It is approximately 135 miles long and 70 miles at its maximum upstream width.

Hydrology

The Grand River originates in the northeast corner of Hillsdale County some 15 miles south of Jackson, Michigan. Six major tributaries are the principal contributors to runoff in the Basin. The Flat, Rogue and Maple Rivers enter the main stream from the north, the Thornapple River from the south, and the Lookingglass and Cedar Rivers from the east. These six streams together with the Portage River near Jackson comprise a total of some 3,200 square miles of drainage area. The remaining drainage area is accounted for by about 30 minor tributary creeks, ranging in size from 65 square miles down to 2 square miles.

Table 2-1

Drainage Areas - Grand River Basin

River	Drainage Area (Square Miles)
Portage	186
Cedar	463
Lookingglass	312
Maple	775
Flat	562
Thornapple	845
Rogue	255
Other Tributaries	2,174
Grand River Total	5,572

Streamflows at specific gage locations are given in Table 2-2.

TABLE 2-2

GRAND RIVER FLOW DATA (1, 2)

Location	Drainage Area Above (Sq. Mi.)	Station Years of Record	Average Dis-charge (cfs)	Instantaneous Flows From Station Years of Record: Minimum Flow (cfs)	Maximum Flow (cfs)	Years of Record Used to Compute Low Flow	7 Day Avg. 1 in 10 Years (cfs)
Grand River at Jackson, Michigan	174	29	113	9.2*	1,070	1935-64	20
Grand River at Eaton Rapids, Michigan	661	14	407	14.0	3,360	1950-64	73
Cedar River at East Lansing, Michigan	355	34	197	3.0	5,920	-	7.5
Grand River at Lansing, Michigan	1,230	35	803	2.8*	24,500	1901-06, 1935-64	75
Lookingglass River at Eagle, Michigan	281	20	160	11	2,860	-	-
Maple River at Maple Rapids, Michigan	434	20	227	4.6	6,500	-	7.4
Grand River at Ionia, Michigan	2,840	13	1,576	105*	21,500	1951-64	175
Flat River at Smyrna, Michigan	528	14	385	7.4*	2,500	-	118
Thornapple River at Caledonia, Michigan	773	20	482	-	6,290	-	113
Rogue River at Rockford, Michigan	234	12	202	30	2,640	-	61
Grand River at Grand Rapids, Michigan	4,900	38	3,370	381	54,000	-	700

*Regulation by upstream control structures.

Topography and Soils

The surface of the Basin is covered with glacial deposits with bedrock outcropping at only two or three locations. The glacial debris consists primarily of sands and gravels on the terminal moraines, the outwash plains and the till plains. Clay, fine sand, silt and finely ground lime are found in the old glacial lake beds. The loamy sands, clays and muck soils are prominent throughout the valley and, because of their fertility and favorable texture, produce high yields of crops.

Climate

The average annual temperature in the watershed is about 49°F. Mean monthly temperatures range from a low of approximately 25°F in January to 72°F in July. Mean monthly precipitation ranges from a low of 1.74 inches in February to a high of 3.5 inches in May, with an average annual precipitation of 32.9 inches (3).

Population

The Grand River Basin had a 1960 population of about 950,000. This estimate is based on an analysis of basin population by minor civil subdivisions. The population of the Basin has grown at a faster rate than the Nation since 1940, increasing by more than 300,000 in that period. In 1960, 67 percent of the Basin's population was municipal. The major cities in the Basin include: Grand Rapids (173,300), Lansing (107,800), Jackson (50,700), and Wyoming (45,800). Table 2-3 shows the 1960 total and municipal population of the Basin and the projected populations for the years 1980 and 2020.

Table 2-3

Present and Projected Populations
Grand River Basin

1960		1980		2020	
Total	Municipal	Total	Municipal	Total	Municipal
950,000	640,000	1,300,000	940,000	2,300,000	2,000,000

Economy

The Grand River includes all or major parts of eleven Michigan Counties.(Barry, Clinton, Eaton, Gratiot, Ingham, Ionia, Jackson, Kent, Montcalm, Ottawa and Shiawassee). Manufacturing is the predominant economic activity in this eleven county area which approximates

the Basin.[4] In 1963, value added by manufacture totalled $1.7 billion. Major industries in the area include transportation equipment, fabricated metals and furniture and fixtures. Table 2-4 shows trends in value added and manufacturing employment. Manufacturing employment has increased to over 150,000 in 1966.

Table 2-4

Value Added by Manufacture
(In 1957-1959 Constant Dollars) and Manufacturing
Employment for the Eleven County Area

	1947	1954	1958	1963
VAM($1000s)	840,000	1,250,000	1,140,000	1,680,000
Mfg. Employment	121,622	127,865	113,954	130,056

Projections of population, manufacturing employment and productivity increases indicate that industrial activity in the Basin may be expected to increase six to seven-fold by the year 2020.

Agriculture is diversified in the Basin with dairying, livestock raising and cash grain farming, all relatively important. Latest estimates indicate there are about 300,000 cattle and calves in the basin.

SECTION 3

WATER USES AND WATER QUALITY REQUIREMENTS

Water Quality Standards

Water quality standards relevant to this study are: 1) the State-Federal standards for Lake Michigan, which is an interstate body of water, established pursuant to the Federal Water Pollution Control Act; and 2) standards established by the State of Michigan for the intrastate Grand River and its tributaries (5). While formal approval of the latter by the Federal government is not mandatory, they are accepted by mutual agreement as defining the objectives of a water quality control program for purposes of this study. Applicable intrastate standards as promulgated by the Michigan Water Resources Commission are set forth below.

Water Supply

(1) All esisting public water supply intakes in normal daily use will be protected for Domestic Water Supply at the point of intake. The following waters will be protected for Domestic Water Supply:

Grand River at Grand Rapids
Rogue River at Rockford

(2) All public waters will be protected for Industrial Water Supply.

Recreation

(1) All natural lakes will be protected for Total Body Contact. The following impoundments will be protected for Total Body Contact:

Name	Water Impounded or Used for Total Body Contact	County	Area to be Protected
Ada Lake	Thornapple River	Kent	From head of Ada Dam.
Cascade Lake	Thornapple River	Kent	Upstream to headwaters of Cascade Lake (48th Street).
Fallasberg Dam	Flat River	Kent	-
Grand River	Grand River	Ottawa	Eastmanville downstream to 160th Ave.
Grand River	Grand River	Kent	Plainfield Road bridge downstream to lower limits of Comstock Riverside Park.

Name	Water Impounded or Used for Total Body Contact	County	Area to be Protected
Ionia Recreation Area	Sessions Creek	Ionia	T6N, R3W, NW 1/4 Sec. 3 downstream to dam.
Lake Geneva	Lookingglass River (not impounded)	Clinton	-
Lake LeAnn	Grand River	Hillsdale	-
Lake Victoria	Alder Creek	Clinton	-
Manitoon Lake	Unnamed Creek	Shiawassee	-
Moore's Park Impoundment	Grand River	Ingham	Waverly Rd. downstream to dam.
Sleepy Hollow Reservoir	Maple River	Clinton	Jason Rd. downstream to dam.
Springbrook Lake	Springbrook Ck.	Shiawassee	-
Thornapple Lake	Thornapple River	Barry	-
Webber Dam Impoundment	Grand River	Goodwin Rd. downstream to dam.	

There are certain waters which, due to physical hazards, have not been designated for total body contact. If these waters in the future become suitable for this use through removal of these hazards the waters will be reconsidered for total body contact use.

(2) All public waters will be protected for Partial Body Contact.

Fish, Wildlife and Other Aquatic Life

All waters designated under the authority of P.A. 26 of 1967 by the Director of the Michigan Department of Conservation will be protected for Intolerant Fish, cold water species. (trout)

The Grand River will be protected for anadromous fish migration from its mouth upstream to the 6th Avenue dam at Grand Rapids.

All public waters will be protected for Intolerant Fish, warm water species except the following which will be protected for Tolerant Fish:

Deer Creek - Grand Trunk and Western Railroad bridge in Coopersville downstream to confluence with the Grand River.

Grand River - Jackson wastewater treatment plant downstream to U.S. 127 expressway bridge.

Grand River - Moore's Park dam downstream to upper dam in Grand Ledge.

Plastic Creek - 28th St. bridge in Grand Rapids downstream to confluence with the Grand River.

Red Cedar River - Harrison Rd. bridge downstream to confluence with the Grand River.

Agricultural

All public waters will be protected for Agricultural.

The above designated uses are not intended to be applicable to drainage ditches. However, Act 245 of the Public Acts of 1929, as amended, prohibits unlawful pollution of any waters of the State of Michigan.

It has been and continues to be the policy of the Water Resources Commission to abate existing pollution and prevent the occurrence of future pollution of all waters of the state including drainage ditches.

There are stretches of streams within the Grand River drainage area where natural water quality may at times be lower than certain parameters of water quality standards specified for a designated use. However, it is intended that the water quality for a designated use be maintained except in those instances where because of natural conditions the quality is lowered.

The water quality standards for the designated use areas shall not apply during periods of authorized dredging for navigation purposes and during such periods of time when the after-effects of dredging degrade water quality in areas affected by dredging. (Water quality standards for the designated use shall apply in areas utilized for the disposal of spoil from dredging operation.)

Where the waters of the Grand River Basin are classified under more than one designated water use, it is intended that the most restrictive individual standards of the designated water uses shall be adhered to.

The use designations adopted by the Commission are in all cases minimal and are not to be interpreted as a license to cause injuries declared to be unlawful by Act 245, P.A. 1929, as amended, or to do any other unlawful act. "The Tolerant Fish, warm-water species use designation will apply only until January, 1974, by which time the waste disposal situations involved are to have been placed before the Water Resources Commission for critical reconsideration, with a view toward the application of higher quality use designations."

TABLE 3-1

WATER

COMMISSION OBJECTIVE:

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS, OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED, OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTRASTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

PARAMETERS / WATER USES	1 COLIFORM GROUP (organisms/100ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A WATER SUPPLY (1.) DOMESTIC Such as drinking, culinary and food processing.	The monthly geometric average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium6: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-8.
(2.) INDUSTRIAL Such as cooling and manufacturing process.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
B RECREATION (1.) TOTAL BODY CONTACT Such as swimming, water skiing and skin diving.	The geometric average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 100.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
(2.) PARTIAL BODY CONTACT Such as fishing, hunting, trapping and boating.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
C FISH, WILDLIFE AND OTHER AQUATIC LIFE such as (growth and propagation)	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	At the average low flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained in rivers capable of supporting: Intolerant fish, cold-water species (trout, salmon) - Not less than 6 at any time. Intolerant fish, warm-water species (bass, pike, panfish) - Average daily DO not less than 5, nor shall any single value be less than 4. Tolerant fish (carp, bullheads) - Average daily DO not less than 4, nor shall any single value be less than 3. Principal anadromous fish migrations in warm-water rivers - Not less than 5 during migrations. At greater flows the DO shall be in excess of these values. For lakes see discussion, page 26	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D AGRICULTURAL Such as livestock watering, irrigation and spraying.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Not less than 3 at any time.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use.
E COMMERCIAL AND OTHER Such as navigation, hydroelectric and steam generated electric power and uses not included elsewhere in these standards.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Average daily not less than 2.5, nor any single value less than 2.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.

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TABLE 3-1 (Cont)

QUALITY STANDARDS

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
Total Dissolved Solids: Shall not exceed 500 as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 75, nor shall any single value exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 10°F.	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	In rivers capable of supporting: — Ambient / Allowable increase / Maximum limit Intolerant fish, cold-water species (trout): 32° to nat. max. / 10° / 70° Intolerant fish, warm-water species (bass): 32° to 35° / 15°; 36° to nat. max. / 10° / 85° Tolerant fish, warm-water species (carp): 32° to 59° / 15°; 60° to nat. max. / 10° / 87° For anadromous fish migrations and inland lakes see discussion, page 29	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0).	Standards to be established when information becomes available on deleterious effects.
Less than 700 dissolved minerals. Maximum percentage of sodium 60% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ when the bases are expressed as milliequivalents per liter.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F.	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.

Interstate Standards

Water quality control planning in the Grand River Basin must consider both intrabasin requirements and the effects of the Grand River on Lake Michigan and downstream waters. Not only have interstate standards been established for Lake Michigan, but there is an ongoing Federal-State enforcement action for the Lake and its tributary basin. Applicable provisions of the interstate standards and their associated implementation plans, as well as initial and subsequent actions of conferees and the Secretary of the Interior in the enforcement proceedings, are binding upon a water quality control program for the Grand River Basin (6).

Present and Future Water Uses

Municipal Water Supply

In 1963 there were 54 communities in the Grand River Basin served by community water supply systems. These facilities served an estimated population of 534,000 and supplied water at the average rate of 89 million gallons per day (mgd). Of this total, approximately 45 mgd were supplied for domestic, public and commercial uses and 43 mgd were supplied for industrial use. Table 3-2 summarizes municipal water use data for the Grand River Basin.

TABLE 3-2

Total Water Intake - Municipal Water Systems, Grand River Basin (1963)

Source	Population Served	Water Intake(mgd)
Surface Water	214,000	35
Ground Water	320,000	54
	534,000	89

Municipal water demands for the major water service areas and projections to the years 1980 and 2020 are presented in Table 3-3. The projections are based upon considerations of population growth, anticipated industrial expansion and projected industrial water use efficiency.

TABLE 3-3

Municipal Water Demands 1963 and Projections to 1980 and 2020 (MGD)

Service Area	Source of Water***	Population Served(1963)	1963 Demand (MGD)	1980 Demand (MGD)	2020 Demand (MGD)
Grand Rapids*	G,S,Lake Michigan & Grand R.	252,000	40.7	68	131
Lansing**	G	127,000	22.4	40	112
Jackson	G	55,000	10.5	16	30
Grand Haven	G	11,000	3.3	5	11
Greenville	G	7,450	1.4	2	4
Hastings	G	7,320	0.8	1	3
Ionia	G	6,700	1.0	2	3
St. Johns	G	5,900	1.0	2	3
Grand Ledge	G	5,770	0.6	1	2
All Others	-	58,000	7.3	28	61
Basin Total		534,000	89	165	360

* Includes Wyoming, Grandville, and East Grand Rapids.
** Includes East Lansing and Lansing Township.
*** S = surface water source, G = ground water source.

Self-supplied Industrial Water

Based on data provided by the U. S. Bureau of the Census in a special tabulation for the FWPCA, it has been determined that the major demand for self-supplied industrial water in the Basin in the Grand Rapids, Lansing, and Jackson areas as shown in Table 3-4. Projections contained in Table 3-4 were developed following consideration of anticipated increases in industrial output and water use efficiency.

TABLE 3-4

Self-Supplied Industrial Water Demands 1959 and Projections to 1980 and 2020

Service Area	1959 Demand(mgd)	1980 Demand(mgd)	2020 Demand(mgd)
Grand Rapids	5	8	14
Lansing	2	3	6
Jackson	6	9	14

Recreation

The study area abounds with natural resources for water-oriented outdoor recreation. There are many lakes in the study area which provide excellent recreational potential. The eastern shore of Lake Michigan around Grand Haven offers a great opportunity for water-oriented recreation. However, a number of the streams and stream sectors within the study area are degraded in water quality to the point that they are not available for most recreational pursuits.

The Bureau of Outdoor Recreation has identified areas of serious water recreation impairment due to water pollution (7). In general, the impaired areas are the harbor water at Grand Haven, the downstream end of the Portage River, and the Grand River below Jackson, Lansing, and Grand Rapids.

The State of Michigan has identified potential parks and camp grounds and is contemplating the construction of reservoirs for recreational purposes (7,8). The need to control water pollution at all such facilities is paramount since such pollution could well jeopardize the very water uses for which the facilities are being planned.

Irrigation

In the Upper Grand River Basin, above Ionia, specialized crops such as mint account for the greatest acreage receiving irrigation. These are followed by potatoes, field crops, cucumbers, pickles, and melons. Non-agricultural irrigation (golf courses, cemeteries, parks, etc.) accounted for 740 of the 4800 acres irrigated in this part of the Basin. The overall results of Michigan Water Resources Commission irrigation surveys indicate that there were 23% more irrigation systems and 28% more acres irrigated in the Upper Grand River Basin during 1960-61 than there were in 1957-58 (8).

In the Lower Grand River Basin truck crops accounted for about 35% of the agricultural irrigated acres with raspberries, blueberries, flowers and nurseries also having significant acreage in irrigation. Of the estimated total of 6500 acres receiving irrigation, cemeteries, parks and golf courses accounted for about 800 acres (9).

The 1959 water usage for irrigation in the Grand River Basin was estimated to average 3.5 mgd during the growing season(10). It is anticipated that this usage will increase threefold by 1980. However, even with such an increase the demand on existing water resources will be minor compared to the total water usage in the Basin.

Fish and Aquatic Life

There are about 260 miles of main stream channels in the Upper Grand River Basin above Ionia. This includes the Grand, Maple, Lookingglass, Cedar, and Portage Rivers. This system offers many opportunities for fishing and duck hunting. A number of reservoirs at power dams furnish expanded fishing and hunting opportunities (8).

In the Grand River Basin there are 12 State Game Project Areas where public hunting and fishing opportunities are provided. Fishing opportunities exist at the Grand Haven State Park. Public fishing sites are available at 48 lakes and streams in the Basin with an area of about 2,100 acreas and frontage of about 21,600 ft. Over 250,000 fish, including trout, bass, pike and bluegills were planted during 1962 in 10 counties within the Basin (11).

Wildlife and Stock Watering

The 1959 agricultural water use for stock watering in the Grand River Basin was about 3.5 mgd (10). Projections of this usage indicate that the demand will increase $1\frac{1}{2}$ times by 1980. The use of water for wildlife and stock watering does not play a significant role in the water supply problems of the Basin.

Hydropower

As of 1965 there were 12 hydroelectric power plants in the Basin, with a total installed capacity of 13,500 kilowatts (KW) and a total average annual generation of 46,400 megawatt hours (MWH). Five of the plants are located on Thornapple River, two are located on the Flat River, one is located on Spring Brook and four are located on the main stem of the Grand River. Five potential hydroelectric sites on the Grand River have been identified by the Federal Power Commission. The sites are located at Grand Rapids, Saranac, Portland, McGee and Danby and would have a total potential capacity of 18,700 KW and a total average annual generation of 65,400 MWH (12).

The use of water for hydroelectric power generation is not considered to be a major use in the Basin. However, water quality problems may develop from the operation of such plants, particularly below dams during off-peak power demands when water releases may be drastically reduced. This can be seen in reviewing Table 2-2.

Commercial Shipping

Grand Haven is one of Lake Michigan's major commercial harbors currently handling in excess of 2½ million tons of commerce annually. Harbor vessel traffic has averaged 2.9 million tons for the period 1955-64, while during 1964 the traffic was 2.6 million tons. The harbor is located at the mouth of the Grand River. A shallow-draft barge channel extends about 15 miles up the Grand River serving commercial sand and gravel deposits, located near the channel's upper end (13).

Cooling Water

As of 1965 the Federal Power Commission reported that there are 14 thermal electric power plants in the Basin. Table 3-5 summarizes data relating to capacity and cooling water intake, when operating at capacity, at each of the 10 steam plants. There are also 4 internal combustion plants in the Basin with an installed capacity of 28,800 KW.

TABLE 3-5

Water Intake-Steam Power Plants
Grand River Basin

Location	Installed Capacity(KW)	Est. Cooling Water Intake(mgd)
Grand Haven	20,000	27
Grand Rapids	20,000	27
Grand Rapids	4,050	6
Grand Rapids	1,250	2
Lansing	81,500	110
Lansing	262,000	353
East Lansing	6,000	8
East Lansing	6,000	8
Eaton Rapids	1,250	2

The use of water for cooling purposes in steam power plants is considered to be significant in the study area with a high level of such use at Lansing. Most cooling waters are returned to streams 12-13°F warmer than at intake. Stream temperatures as high as 90°F have been recorded below the power stations at Lansing (14).

Waste Assimilation

Use of streams in the Grand River Basin for waste assimilation is one of the predominant present day uses, and in several locations it is the cause of extreme water quality problems as discussed in Sections 4 and 6.

Esthetics

The use of water for esthetic enjoyment is an intangible benefit which is directly related to the availability of clean water. It is a very important factor in determining the recreational potential of the Grand River Basin. Camping, picnicking, and sightseeing are more enjoyable when accompanied by pleasing lakes and streams of high quality water. Pollution robs the water of its esthetic value for such water related activities. Since this Basin will be called upon to provide recreation for many people living both within and outside the Basin, it is very important that the waters of the area be kept esthetically pleasing.

Beyond its importance to recreation the maintenance of an esthetically pleasing habitat for the present and future millions of residents of the Basin is essential to the economic and social well being of the area.

SECTION 4

PRESENT WATER QUALITY AND PROBLEMS

General

Two programs of study were carried out by the GLIRB Project with respect to water quality in the Grand River Basin. The first consisted of weekly sampling of the river mouth to determine average annual loadings discharged to the Lake and water quality variability. The second consisted of intensive studies of two stream stretches of the Grand River to determine the effect of organic wastes on stream oxygen resources.

Grand River Mouth Sampling

Physical and Chemical Findings

During the period from March 1963 through April 1964, the GLIRB Project collected samples at the mouth of the Grand River to determine loadings of various substances being carried into Lake Michigan. The analytical results of this sampling are shown below in Table 4-1. Of all the chemical parameters reported, the two nutrients, total phosphorus and ammonia nitrogen, are most illustrative of the waste inputs discharged to Lake Michigan by the Grand River.

Considering all Lake Michigan tributaries, the Grand River is one of the greatest contributors of phosphorus and ammonia nitrogen with inputs of 1777 and 6970 pounds per day, respectively. In general, the chemical parameters for given streams in the Lake Michigan Basin follow definite patterns. In the Grand River, phosphorus and ammonia nitrogen concentrations are high and a pattern of high values is also seen for the other chemical parameters as shown in Table 4-1. The Grand River is also one of the major contributors of dissolved substances to the Lake.

Table 4-1

Water Quality - Grand River at Mouth
March 1963 - April 1964

Parameter	No. of Samples	Concentration (mg/l) Average	Range	Loading (lbs/year)
Phosphorus (Total Soluble)	52	0.17	0.04-0.36	648,600
Ammonia Nitrogen(NH_3-N)	52	0.68	0.05-1.5	2,544,000
Nitrate Nitrogen(NO_3-N)	51	0.72	0.04-2.4	
Organic Nitrogen(Org.-N)	52	0.77		
Total Dissolved Solids	51	350	275-570	
Total Suspended Solids	44	24	6-84	
Sulfates (SO_4)	52	74	56-100	
Chlorides (Cl)	52	42	19-67	
Silicon Dioxide(SiO_2)	52	5.3	2.5-17	
Calcium (Ca)	52	72	51-85	
Magnesium (Mg)	52	26	16-30	
Sodium (Na)	52	28	7.1-43	
Potassium (K)	52	2.8	2.1-3.9	
Alkyl Benzene Sulfonate (ABS)	52	0.28	0.11-0.73	
Copper (Cu)	52	0.14		
Cadmium (Cd)	52	*		
Nickel (Ni)	52	0.04		
Zinc (Zn)	52	*		
Chromium (Cr)	52	0.04		
Lead (Pb)	52	0.11		

* Not Detected at Test Sensitivity.

The maximum phenol concentration on the eastern side of Lake Michigan was 7.2 micrograms per liter (ug/l) close to the mouth of the Grand River. BOD_5 values as high as 8.6 mg/l were recorded near the mouth. An average total chromium concentration of 0.04 mg/l was found at the mouth of the Grand River. This concentration is only slightly less than the Public Health Service Drinking Water Standards(22) mandatory limit of 0.05 mg/l for hexavalent chromium (15).

Radiochemical Findings

The analytical results from 1963 sampling in the Grand River at the mouth are shown below in Table 4-2.

Table 4-2

Radioactivity
Grand River at Mouth
1963 Average

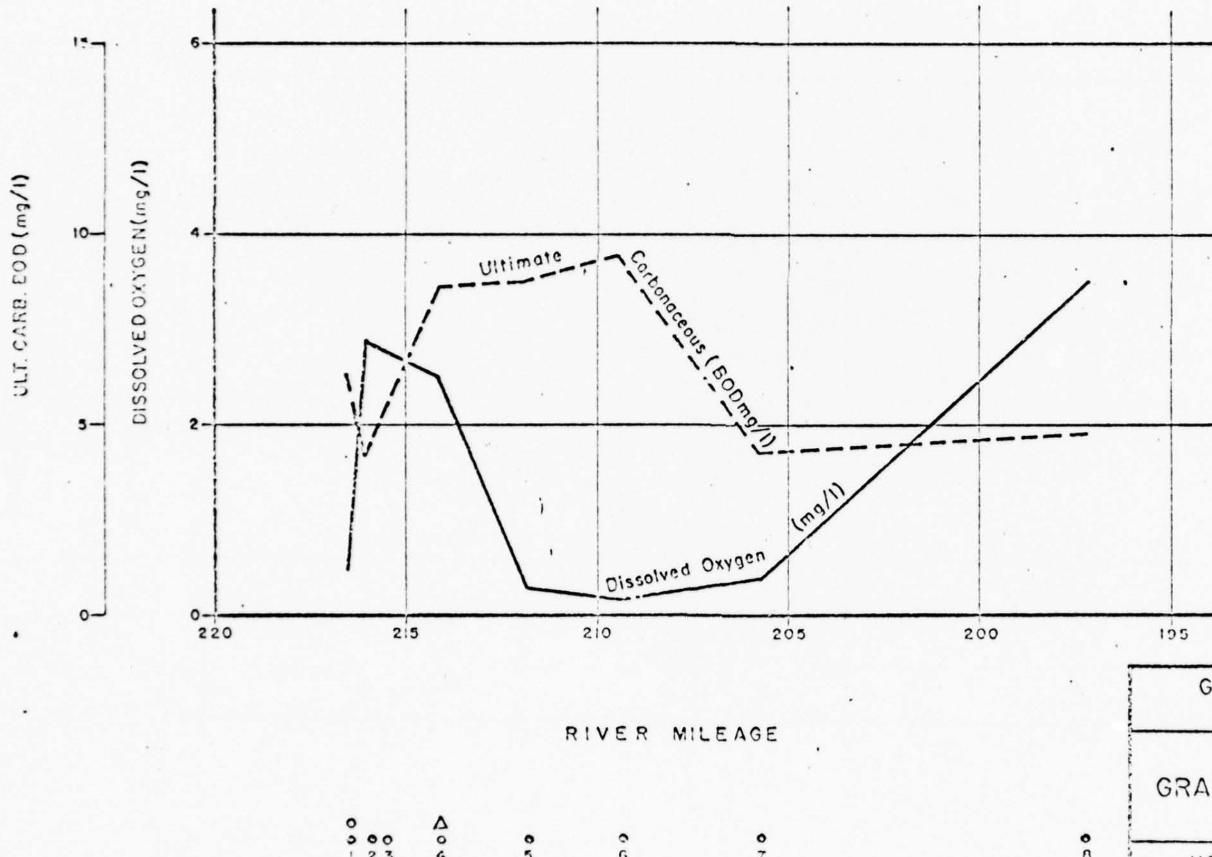
Portion	Gross Alpha Concentration (pc/l)	Gross Beta Concentration (pc/l)
Suspended Solids	<1	4
Dissolved Solids	<1	12
Total Solids	<1	16

In relation to the Public Health Service Drinking Water Standards, the concentrations reported above meet the Standards. However, a specific determination of the Strontium -90 concentration would be necessary in order to verify that the concentration was equal to or less than 10 picocuries per liter (pc/l). Past experience with similar waters shows that a very small portion of the gross beta activity is from Strontium -90.

Grand River Intensive Studies

Physical and Chemical Findings

The effects of organic loadings on the oxygen resources of the Grand River below Jackson and Lansing are indicated in the profiles of the dissolved oxygen (DO) and biochemical oxygen demand (BOD) shown in Figures 4-1 and 4-2.



LEGEND

- ● Sampling Station
- ○ Sewage Treatment Plant
- Δ Tributary

1. Jackson Sewage Treatment Plant
2. Parnell Rd.
3. Jackson State Prison STP (Wading Sta)
4. Portage River
5. Maple Grove Rd.
6. Berry Rd. Bridge
7. Churchill Rd. Bridge
8. Tompkins Rd. Bridge

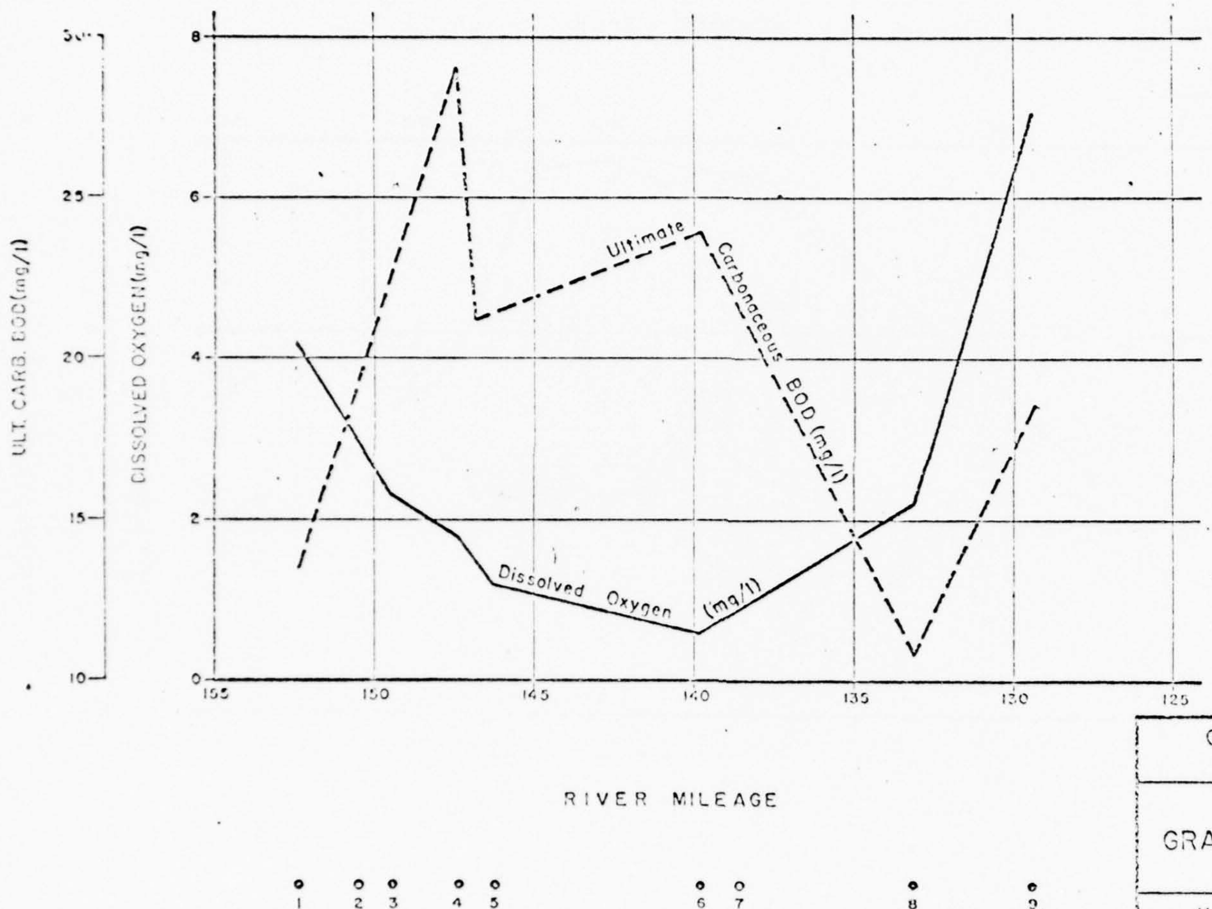
NOTE:
Analytical Results Plotted Are Mean Values From Intensive Sampling (5:00 to 7:00 AM)

GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

DO & BOD PROFILES
GRAND RIVER BELOW JACKSON
July 9, 1964

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

FIGURE 4-1



LEGEND

- ● Sampling Station
- ○ Sewage Treatment Plant

1. Grand River Ave.
2. Lansing Sewage Treatment Plant
3. North Waverly Rd.
4. Wading Station
5. Canal Rd. Bridge
6. Highway M-100
7. Grand Ledge Sewage Treatment Plant
8. Jones Rd. Bridge
9. Turner Rd. Bridge

NOTE:
Analytical Results Plotted Are Mean Values From Intensive Sampling (5:00 to 7:00 A.M.)

GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

DO & BOD PROFILES
GRAND RIVER-BELOW LANSING
July 15, 1964.

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

FIGURE 4-2

In Figure 4-1 the apparent effects of effluent aeration at the Jackson sewage treatment plant are shown with a rise in the stream DO from about 0.4 mg/l to 3 mg/l in a distance of about 0.5 mile below the plant discharge. The stream DO concentration then decreases rapidly to a low of about 0.2 mg/l at a point about 7 miles below the plant discharge. The highest DO concentration in the study reach, 3.5 mg/l, was found at a point about 19 miles below the Jackson plant discharge. Desirable fish and aquatic life cannot survive under such degraded oxygen conditions.

In Figure 4-2 the high BOD levels, reaching a maximum of 29 mg/l about 3 miles below the Lansing Sewage Treatment Plant discharge, result in DO levels below 3 mg/l for a 19 mile stretch below the Lansing plant. The minimum DO, about 0.6 mg/l, occurs about 10.5 miles below the Lansing plant. As was the case below Jackson, desirable fish and aquatic life cannot survive below Lansing due to the degraded oxygen conditions. The stream is also unsuitable for other beneficial uses.

Further demand on the oxygen resources of the Grand River below Lansing results from the thermal discharges of the steam electric generating stations at Lansing. Increases in stream temperatures below the stations result in a higher rate of biological activity and a more rapid uptake of dissolved oxygen. The increased temperatures also limit the total amount of dissolved oxygen available for waste assimilation due to a lowering of oxygen saturation values.

The Grand River in the stream reaches below Jackson and Lansing was also found to be esthetically unpleasing and objectionable for recreational uses such as boating, water skiing, and similar aquatic sports. The organic loadings causing these polluted conditions originate from the discharges of municipal sewage treatment plants. The major municipal waste discharges are listed in Table 5-1.

Microbiological Findings

Limited microbiological studies were conducted in conjunction with the intensive DO - BOD studies below Jackson and Lansing. Analyses for both total coliform and fecal streptococcus organisms were made.

Below Jackson, 11 samples were collected at eight stations and analyzed for coliform and fecal streptococci. Total coliform organisms reached a maximum density of 230,000 per 100 ml. At a point about 1.5 miles below the Jackson sewage treatment plant discharge and 0.5 mile below the Prison plant discharge. The maximum

fecal streptococcus density was 6400 organisms per 100 ml. About 0.5 mile below the Jackson plant discharge, the maximum densities were found in samples collected October 14, 1964.

Below Lansing 17 samples were collected at eight stations. Total coliform organisms reached a maximum density of 930,000 per 100 ml during the May 13, 1964 sampling, at a point approximately 1 mile below the Lansing sewage treatment plant discharge. The maximum fecal streptococcus density was found at a point about 5.5 miles below the Grand Ledge sewage treatment plant discharge, reaching 12,000 organisms per 100 ml during the October 14, 1966 sampling.

The bacterial densities reported above indicate a high degree of pollution most likely resulting from the discharge of wastes from the municipal sewage treatment plants at Jackson, the State Prison, Lansing and Grand Ledge. Since January 1967 the state has required continuous disinfection. The effectiveness of chlorination in reducing the high coliform counts has not been determined.

SECTION 5

WATER QUALITY CONTROL
(WASTE SOURCES AND CONTROL MEASURES)

General

The problems of water quality control in the Grand River Basin are complex. Solutions to these problems will of necessity involve a comprehensive program which includes construction of new sewerage facilities; and continuous and intensive monitoring of operating procedures, treatment plant efficiency, and water quality conditions to determine necessary additional construction and operation needs as they arise. In addition, some combination of advanced waste treatment and flow regulation may be required to attain the desired water quality below Jackson and Lansing. The following paragraphs present information on waste sources, projected waste loads and water quality improvement measures which should be employed.

Waste Sources

The Grand River and the streams tributary to it receive an estimated organic waste load of 32,000 pounds of 5-day biochemical oxygen demand (BOD_5) per day. Approximately 15,000 pounds are from industries with separate discharges. The most significant waste loads in terms of water use impairment are discharged at Jackson and Lansing.

The following paragraphs summarize the major waste sources in the Basin. Consequences of these discharges were discussed in Section 4.

Municipal

Approximately 540,000 people were served by 47 municipal sewerage systems in the Grand River Basin in 1962 (16).

Of the 47 municipal sewerage systems 18 provide minor or no treatment. Of the remaining 29 systems, 9 provide only primary treatment, (sedimentation and sludge disposal) and 20 provide secondary treatment (primary treatment plus filtration or activated sludge). Major municipal sewerage facilities having connected populations of 5,000 or more are listed in Table 5-1, and their locations are shown on Figure 1-1.

TABLE 5-1

MUNICIPAL WASTE INVENTORY OF MAJOR COMMUNITIES
GRAND RIVER BASIN (16)

Community	Receiving Stream	Miles Above Mouth of Grand River	Treatment	Population Connected	Population Equivalent Estimated Waste Untreated	Population Equivalent Estimated Waste Treated	%BOD5 Reduction
Jackson	Grand River	216.4	Secondary	51,000	53,000	3,690	93
Jackson State Prison	Grand River	214.2	Secondary	6,500	11,400	1,600	86
East Lansing	Cedar River	160.0	Secondary	35,000	50,000	5,000	90
Lansing	Grand River	150.5	Secondary	130,000	170,000	17,000	90
Grand Ledge	Grand River	138.6	Primary	5,100	6,600	4,300	35
Saint Johns	**Hayworth Creek**	121.3	Secondary	5,600	7,300	1,415	81
Hastings	Thornapple River	102.8	Primary	6,350	8,250	5,350	35
Greenville	Flat River	98.1	Primary	7,400	9,600	6,250	35
Ionia Ionia State Reformatory	Grand River	89.2	Primary	6,600	8,600	5,600	35
Grand Rapids	Grand River	40.6	Secondary	220,000	285,000	28,500	90
Grandville	Grand River	34.3	Secondary	8,000	4,800	500	90
Wyoming	Grand River	-	Secondary	56,000	36,000	6,900	81
Grand Haven	Grand River	1.0	Primary	11,000	14,300	9,300	35

TABLE 5-2

MAJOR INDUSTRIAL WASTE DISCHARGES
GRAND RIVER BASIN (17)(18)

Company Location	Receiving Stream	Miles Above Mouth of Grand River	Treatment	Waste Discharge			Estimated Treatment Efficiency BOD Removal
				Flow MGD	BOD_5 lbs/day	Susp. Solids lbs/day	
Packaging Corp. of America Grand Rapids	Grand River	40.6	**Save-All**	2.5	3,000	6,500	0
Eagle Ottawa Leather Company Grand Haven	Grand River	1.0	Screening	1.4	16,000	24,000	5
Rockford Paper Mills Inc. **Childsdale**	**Rogue River**	56.0	**Clarifiers**	1.0	1,200	4,000	10

Industrial

Industries with separate outfalls discharge approximately 21,000 pounds of BOD_5 daily to the streams of the Grand River Basin (17). Major industrial waste sources in the Grand River Basin are listed in Table 5-2.

Combined Sewers

It has been estimated that a quantity, equivalent to 3 to 5 percent of all untreated waste-water flow in combined sewer systems, is annually discharged to streams by overflows (19). A far greater percentage of the solids are discharged to streams from overflows due to the fact that the sludge deposited in the sewers is flushed out by the storm flow.

Of the 47 communities with public sewer systems in the Area only about 8 have completely separate sewer systems. The types of sewer systems of the major municipal waste source are listed in Table 5-3.

TABLE 5-3
Types of Municipal Sewer Systems
Major Municipal Waste Sources
Grand River Basin (20)

Municipality	Type of Sewer System
Jackson	Combined
East Lansing	Separate and Combined
Lansing	Separate and Combined
Grand Ledge	Separate and Combined
Saint Johns	Separate and Combined
Hastings	Combined
Greenville	Combined
Ionia	Separate and Combined
Grand Rapids	Separate and Combined
Grand Haven	Combined

Steam Power Plants

Thermal discharges from two steam generating stations at Lansing, Michigan are particularly significant from a water quality standpoint. The temperatures of 90°F reported by the Michigan Water Resources Commission were measured prior to the installation of additional generating capacity at Lansing (14). Unless control measures are instituted, the temperature standards for fish and aquatic life will not be maintained.

Agriculture and Land Runoff

Fertilizer

Estimates of fertilizer use in the Grand River Basin are that approximately 8,000 tons of nitrogen and 5,000 tons of phosphorus are being used annually. The applications of these are projected to increase four and two-fold, respectively, by 2020.

During 1963 - 1964 the FWPCA conducted a rural land runoff sampling study to assess the relative amounts of phosphorus and other substances transported to streams by rural runoff in the Lake Michigan Watershed. Based upon the results of this study, it is estimated that there is an annual total soluble phosphorus runoff from rural land of about 100,000 pounds per year in the Grand River Basin.

Pesticides

Pesticide contamination of streams is a matter of growing concern. Agricultural activity is considered to be a major source of the pesticides which have been found in water (22). Insecticides used in the Grand River Basin include Diazinon, Guthion, Malathion, Parathion, Sevin, Thiodan, and Toxaphene. The general use of DDT has been banned in the State of Michigan. Unfortunately, there is little or no information available as to the amounts that are used in the Basin. The Four State-Federal Lake Michigan Enforcement Conference's Pesticide Committee recommended a monitoring program for the entire Basin. This program is being implemented by the states and the FWPCA. The data thus obtained will provide a basis for control measures to insure protection of the Basin's wildlife.

Ships and Boats

Commercial Shipping

The large number of vessels plying Grand Haven Harbor represents a considerable potential for pollution of the Harbor waters. Among the possible sources of pollution are cargo spillage, dunnage, bilge waste, ballast water, fuel spills, garbage and sanitary wastes. Uncontrolled discharges of these wastes can result in serious pollution problems to beaches, shore property, recreational waters, fish and aquatic life, and municipal and industrial water supplies.

Commercial shipping has increased significantly since the opening of the St. Lawrence Seaway in 1959. While all new vessels built since 1952 specifically for use on the Great Lakes have been equipped with waste treatment facilities, ocean-going ships generally have no provisions for waste treatment. The majority of these ocean-going vessels are designed to discharge sanitary wastes from multiple outlets.

The U. S. Public Health Service has established regulations governing vessel waste discharges in the Great Lakes based upon their legal responsibility for the interstate control of communicable diseases. Restricted areas have been established in which the discharge of sewage, or ballast or bilge water, from vessels is prohibited. Restricted areas include the water within a three mile radius of domestic water intakes(23). Additional controls were recommended by the conferees to the Four State-Federal Lake Michigan Enforcement Conference.

Recreational Boats

In addition to commercial traffic, Grand Haven Harbor is also an important recreational boating center. About 4000 recreational craft annually are passed through the Spring Bridge which joins Ferrysburg and Spring Lake. There are numerous marinas and boat clubs along the lower part of the Grand River. Many of the larger recreational craft are equipped with galley and toilet facilities which may discharge untreated or inadequately treated wastes to the Harbor or Lake waters. Oil and gasoline wastes, as well as garbage and sewage from onboard cooking and toilet facilities, are the major potential sources of pollution. The State of Michigan has recently adopted rules and regulations to control pollution from this source. These rules became effective on January 1, 1970.

Dredging

Maintenance dredging is done by the U. S. Army Corps of Engineers to maintain authorized navigation depths in Grand Haven Harbor. Dredged materials are disposed of in the deep waters of Lake Michigan.

Water quality surveys made in 1967 by the FWPCA showed significant evidence of pollution material in the bottom deposits of Grand Haven Harbor. Transfer of this pollutional material to Lake Michigan via the dredging process creates an additional zone of pollution in the Lake.

Through a joint statement announced March 1, 1967, the Department of the Army and the Department of the Interior agreed on a program and plan for attacking the problem of the disposition of polluted material dredged from harbors in the Great Lakes. It was agreed that, in order to maintain navigation, the Corps of Engineers would proceed with dredging in calendar year 1967 on 64 channel and harbor projects in the Great Lakes. The Corps also initiated a two-year pilot program early in 1967 to develop alternative disposal methods which would lead to a permanent plan of action.

Transport to Streams and Lakes from Rural Lands

The amount of soluble phosphorus reaching streams from land runoff, in the Grand River Basin, as estimated from samples taken on eight pilot watersheds, as previously discussed, is about 100,000 pounds annually. Although there are many factors which affect phosphorus contributions from rural areas, including methods of applying fertilizers, quantities applied, type of soil, topography, rainfall, land use practices and soil cover, it is believed that the results obtained are reasonably representative of the Grand River Basin.

Municipal Sources

Domestic sewage is relatively rich in phosphorus compounds. Most of this phosphorus comes from human excreta and synthetic detergents. The amount of phosphorus released by human metabolic processes is a function of protein intake and for the average person in the United States, this release is considered to be about 1.5 grams per day (24). Synthetic detergent formulations contain large amounts of phosphorus. It is estimated that 2.5 grams of phosphorus per capita-day are discharged to sewer systems as a result of the use of synthetic detergents.

When the above per capita figures for phosphorus from human excreta and detergents are expanded to cover the entire sewered population of the Grand River Basin the quantity becomes quite large. Data from waste inventories show that 540,000 people are served by sewer systems in the Basin. It is estimated that a total of approximately 1,100,000 pounds of soluble phosphorus from humans and detergents are discharged to the waters of the Basin each year.

Tributary Mouth Sampling

In addition to the land runoff sampling from the eight small subbasins discussed above, sampling stations were established at the mouth of the Grand River. These stations were sampled intermittently for one year during the same period in which the land runoff stations were sampled.

Sampling at the mouth made it possible to estimate the total phosphorus load reaching Lake Michigan from the Grand River. It was determined that a total of approximately 648,600 pounds of phosphorus is discharged to the Lake annually.

Municipal Waste Treatment Needs

The immediate goal in the treatment of municipal wastes is the provision of biological (secondary) treatment or its equivalent at each waste treatment plant. Such treatment is the minimum considered adequate in terms of present technology. This need is especially important in those areas where consideration is being given to low-flow augmentation to assist in maintaining water quality standards. Augmentation cannot be considered as a substitute for secondary treatment. There is also a present need to increase total phosphorus removal to at least 80% as recommended by the Four State-Federal Enforcement Conference on the Pollution of Lake Michigan and its Tributary Basin. All municipal waste treatment facilities in Michigan are required to provide waste disinfection on a year around basis.

Industrial Waste Treatment Needs

Minimum treatment needs for major industries with separate outfalls are listed in Tables 5-4. In developing this list it was considered that the equivalent of secondary waste treatment as described in the preceding section would be the minimum degree of treatment required.

Combined Sewer Overflow Control

The need for solutions to the problems caused by overflows from combined sewer systems is pressing and is receiving much current attention(25). The Water Quality Act of 1965 established a four-year program of grants and contract authority to demonstrate new or improved methods to eradicate the problems of combined sewer overflows.

While economically feasible methods for solving the problems are being developed, existing combined sewer systems should be patrolled and overflow regulating structures should be adjusted to convey the maximum practicable amount of combined flows to and through waste treatment facilities. Combined sewers should be prohibited in all newly developed urban areas and should be separated in coordination with urban renewal projects.

TABLE 5-4

WASTE TREATMENT NEEDS FOR MAJOR INDUSTRIAL WASTE SOURCES
GRAND RIVER BASIN

Company	Location	Treatment Facilities	
		Present	Recommended Minimum
Packaging Corporation of America	Grand Rapids	None	Secondary
Eagle Ottawa Leather Company	Grand Haven	Screening	Secondary
Rockford Paper Mills Inc.	Childsdale	Clarifiers	Secondary

Plant Operation

Proper plant operation must follow proper plant design in order to efficiently reach the goals of water pollution control. The importance and value of proper plant operation must be emphasized at all levels of public authority. Effective operation can be encouraged by means of a routine inspection program. Inspections should be conducted by the appropriate State agencies on at least an annual basis for the small and medium-sized plants, and at least twice a year for the larger plants.

The Michigan Department of Health administers a mandatory sewage treatment plant operators' certification program. A similar program for the operators of all commercial and industrial waste treatment facilities, administered by the Water Resources Commission, will go into effect January 1, 1971. State sponsored operator training programs are also a useful tool for elevating the level of overall plant performance. Today, with increasing activity in the field of water pollution control at the Federal, state and local levels, operator training courses should be conducted at least annually. The Michigan program, consisting of annual training on a regional basis, compares favorably with the training programs sponsored by other states.

Monitoring

The maintenance of desirable water quality on a continuing basis calls for a routine monitoring program covering the significant water quality parameters at strategic points.

The overall monitoring program should be geared to provide an adequate picture of all wastes being discharged to the waters of the Basin and adjacent waters of Lake Michigan and serve to indicate trends in water quality or the need for additional water quality improvement measures.

As part of an overall monitoring program efforts are needed to assess the potential problems associated with agricultural practices in the Grand River Basin. There is a lack of information concerning land use practices and the quantities of pesticides and fertilizers applied within the Basin. Reliable data concerning application rates on a yearly and seasonal basis in each county would be very helpful in identifying potential water quality problem areas.

At present, water quality monitoring in the Grand River Basin is conducted by three agencies: Michigan Water Resources Commission, Grand River Watershed Council, and Michigan State University. All of these utilize FWPCA's national water quality data handling system - STORET - for the storage, retrieval and statistical analysis of their data. Approximately 80 stations are presently being sampled within the Grand River Basin.

State Water Pollution Control Program

The Federal Water Pollution Control Act recognizes the primary responsibility of the States in the control and prevention of water pollution. The effectiveness of a State program, however, is dependent upon adequate funds and personnel with which to accomplish this mission.

The State of Michigan has achieved commendable success in the control of water pollution with the staff and funds available. However, even though much has been accomplished by the State in controlling conditions, much remains yet to be done. In 1964, the Public Administration Service prepared a survey report for the Public Health Service concerning the budgeting and staffing of State programs (26). This report contains suggested guidelines for use in evaluating the adequacy of State water pollution control programs. This report suggests a minimum total staff level of 110 persons and a desirable total staff level of 171.

In view of the water pollution control problems still existing in the Basin consideration should be given to an accelerated program to match the needs for clean water for all legitimate uses. An accelerated State water pollution control program utilizing fully the resources and programs of the Federal Water Pollution Control Administration will ensure the earliest possible accomplishment of our common goal - more effective use of our water resources.

Streamflow Augmentation Requirements

After studying the location of major municipal and industrial waste discharges to the Grand River and tributaries and the quantitative and qualitative characteristics of the receiving waters, two reaches of the main stem of the Grand River below Jackson and Lansing indicated potential benefits from flow augmentation and were selected for waste assimilation studies.

Waste assimilation studies were conducted to determine the total streamflow required to meet a range of water quality goals in the Grand River below Jackson and Lansing. During 1964 intensive stream investigations were conducted on these reaches during May, July and October.

A computer program was utilized to develop a mathematical model which reproduced the stream conditions observed during these intensive sampling periods. Using projected flow and quality data for the waste inputs within the study reaches of the stream, the model was used to compute the total streamflows required for flow regulation for water quality control. It has been assumed that a 90% BOD_5 removal will be provided for both municipal and industrial waste discharges.

The State of Michigan has set a minimum standard of 4.0 mg/l of dissolved oxygen below both Lansing and Jackson. The maintenance of this standard for dissolved oxygen, in conjunction with the other water quality standards listed in Section 3, will assure the absence of nuisance odor conditions; permit recreational use involving partial body contact; support pollution tolerant fish such as carp and other aquatic life; and in general, provide for the esthetic enjoyment of clean surface waters.

The Michigan Water Resources Commission has designated the reaches of the Grand River directly below both Lansing and Jackson as Tolerant Fish, warm-water species use areas. This designation requires an average daily dissolved oxygen level of not less than 4.0 mg/l. The Commission, however, has adopted the Tolerant Fish, warm-water species use designations in all intrastate waters only for a five year period, ending January, 1974. It is the Commission's policy that before that date, the waste disposal situations involved are to be reconsidered with a view toward the application of higher quality use designations.

The maintenance of a 4.0 mg/l dissolved oxygen level below Lansing and Jackson should, therefore, only be regarded as an interim objective. To fully implement the Commission's policy, the staff of the Commission believe that due consideration will have to be given to the feasibility of maintaining a higher minimum dissolved oxygen level.

The estimated ranges of total streamflow required to maintain a DO concentration of 4.0 mg/l below Jackson are 53 to 510 cfs in 1980 and 103 to 860 cfs in 2020. Below Lansing the streamflows required to maintain a DO of 4 mg/l are 55 to 480 cfs in 1980 and 160 to 1760 cfs in 2020. Ranges in streamflow requirements are primarily due to the wide variation in stream temperatures over the year. These streamflow requirements satisfy both carbonaceous and nitrogenous cycles.

The ability of existing streamflows to meet the above demands can be assessed by comparing the estimated maximum required flows in 1980 and 2020 with the 7-day once-in-10-year low flows as shown in Table 2-2. The comparison indicates that existing low flows will not be adequate to assimilate the treated waste discharges at Jackson and Lansing in 1980 and 2020. Thus, it is concluded that some combination of streamflow regulation and advanced waste treatment will be required to achieve the water quality goal of 4 mg/l DO below Jackson and below Lansing. Streamflow requirements to maintain the required DO levels are shown by months in Table 5-5

TABLE 5-5

Average Monthly Streamflow Necessary to Maintain
Stated Minimum Dissolved Oxygen Levels in the Grand River, Michigan*
(DO goal 4 mg/l)

	Below Jackson cfs			Below Lansing cfs			
Year	1966	1980	2020	1966	1980	2020	
Month							Temp. °C
April	57	76	155	53	85	250	6
May	126	169	317	114	185	520	14
June	195	274	480	172	290	780	18
July	250	362	630	218	360	1020	20
August	345	510	860	290	480	1760	22
September	195	274	480	172	290	780	18
October	157	212	385	140	230	630	16
November	91	123	238	85	110	390	11
December	57	76	155	53	85	250	6
January	42	53	103	25	55	160	0
February	45	58	112	30	60	180	1
March	45	58	112	30	60	180	1

*Note: Streamflows are exclusive of municipal, industrial and institutional waste discharges.

SECTION 6

BENEFITS AND ALTERNATIVES

General

Benefits to be derived from water supply and water quality control are determined on the basis of the least costly alternative method or combination of methods which, in the absence of multipurpose reservoir projects, would provide an adequate water supply or result in meeting a given water quality level. Alternatives considered in the case of water supply include storage reservoirs in the Grand River Basin itself, transportation of water from outside the Basin and expansion of existing well supplies. Water quality control alternatives include storage reservoirs in the Grand River Basin itself, transportation of water from outside the Basin and higher degrees of waste treatment.

Policy changes regarding the provision of storage for water quality management in Federal water resource projects are presently under consideration by the Water Resources Council. In a memorandum to the Council in June 1967, the Secretary of the Interior made a number of recommendations relative to the evaluation of benefits resulting from the maintenance of water quality by means of the regulation of stream flow. As was indicated in a subsequent restatement of Interior's views in October 1968, the objective of these recommendations is to obtain more effective consideration in the planning for water quality control as a supplement to high degrees of waste treatment in the meeting of water quality standards.

Reservoir Sites

Approximately 75 possible Grand River Basin reservoir sites have been identified by the U. S. Army Corps of Engineers. These sites have been depicted by means of colored overlays on Michigan Department of Conservation County maps. A set of these overlay maps was used to obtain pertinent information, such as the location, storage volume and drainage area of each of the proposed sites. This information permitted tentative selections of reservoir sites which could be used for the purpose of water storage for water quality control to serve the areas previously outlined. At the writing of this appendix no final decision had been made as to which reservoir projects would actually be constructed.

Possible reservoir sites are shown schematically on Figure 6-1 and described in Tables 6-1 and 6-2. These possible sites were selected from the overlay maps on the basis of size and location. In estimating the storage that could be obtained for the purposes of water supply or water quality control, the average annual flow was utilized. A factor of 0.7 cfs per square mile (Lansing Gage) was used to estimate the average discharge at the various reservoir sites. If the estimated average annual volume of flow was less than the storage available at a site then the lower volume figure was used to determine the storage available for water supply or water quality control.

Water Supply

Data on municipal and municipally supplied industrial water use was presented in Section 3. Based on projected water needs given in that section and comments obtained from the U. S. Geological Survey, it appears that ground sources of municipal water supply will be insufficient to meet the demands of 2020. The water demand at Lansing will reach 118 mgd. Some 90 mgd of this amount will be supplied from ground water sources. A single-purpose reservoir may be considered as a possible water supply source, to augment the well supply.

Development of the Williamston site on the Red Cedar River as a single-purpose water supply reservoir would cost approximately $10,000,000.

One alternative to construction of a reservoir as described above would be to obtain water from one of the Great Lakes. A connection with Lake Erie would require the construction of a 60-inch diameter pipeline 80 miles in length and 9 pumping stations. The construction of such a project would cost about $30,000,000. This is based on a cost of $60 per lineal foot of pipe and $52,000 per pumping station. Right of Way costs would be approximately $5,200,000.

Water Quality

Jackson

An average annual discharge of 187 cubic feet per second (cfs) will be required by 1980 and 336 cfs by 2020 as one alternative method of meeting the water quality needs in the Grand River below Jackson.

Another alternative method is advanced waste treatment (AWT) resulting in an effluent which is essentially stable. In light of the limited storage available above Jackson, AWT is probably also the most feasible alternative.

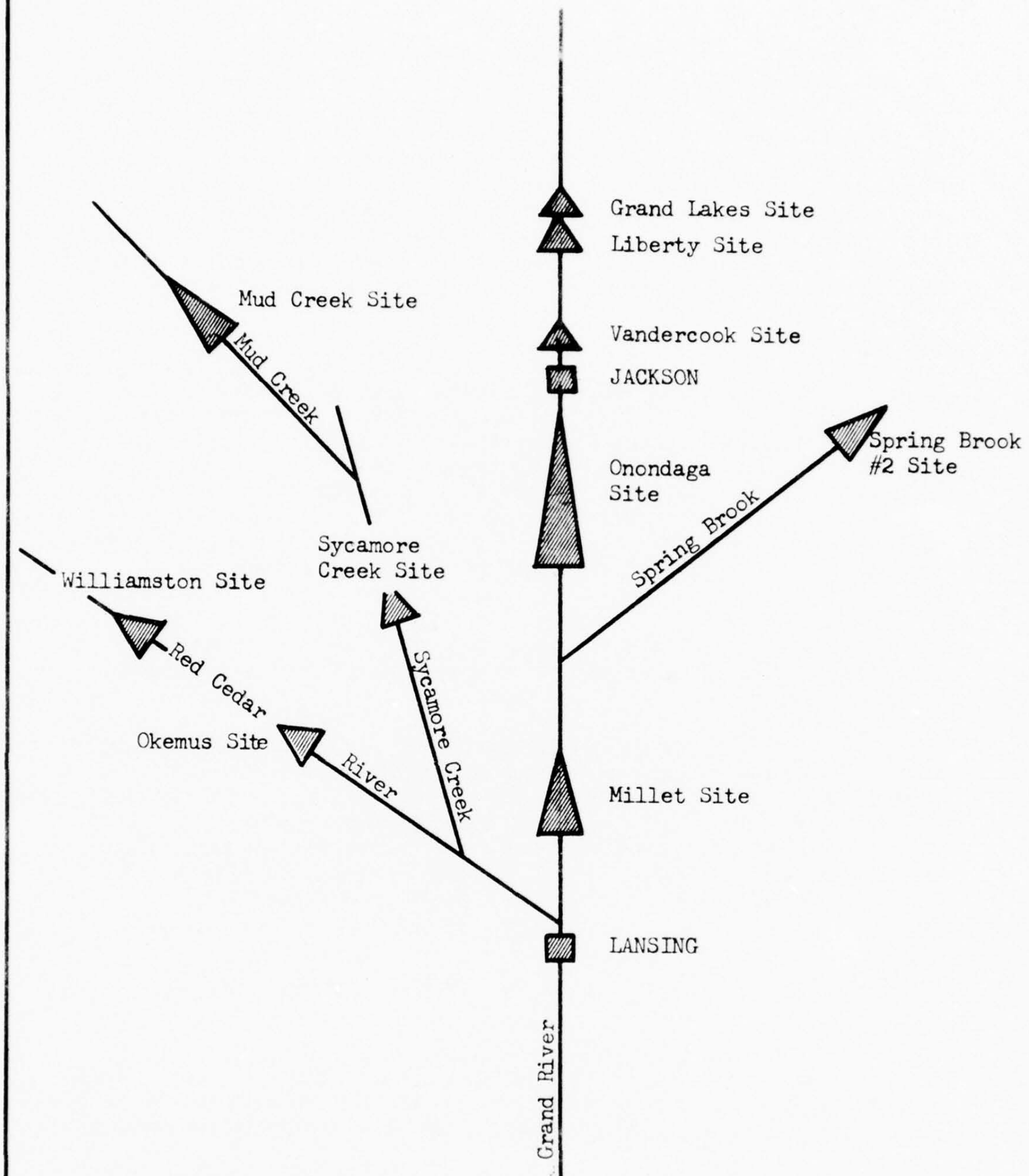


FIGURE 6-1

CHICAGO PROGRAM OFFICE
POSSIBLE RESERVOIR SITES LANSING & JACKSON, MICH.
U.S. DEPARTMENT OF THE INTERIOR FEDERAL WATER POLLUTION CONTROL ADMINISTRATION GREAT LAKES REGION CHICAGO, ILLINOIS

TABLE 6-1

POSSIBLE RESERVOIR SITES
ABOVE JACKSON

1 LOCATION	2 STORAGE VOLUME AVAILABLE (Acre-feet)	3 DRAINAGE AREA AT DAM SITE (Square Miles)	4 AVERAGE STREAMFLOW AT DAM SITE (Cubic Feet/Second)	5 STREAMFLOW AVERAGE ANNUAL (Acre-feet)	6 AVAILABLE STREAMFLOW (Acre-feet	7 RATIO 6/2
Grand Lakes	7500	10	7	5068	<u>5068</u>	0.7
Liberty	<u>4300</u>	25	18	13030	7962	1.9
Vandercook	<u>6900</u>	53	37	26780	17412	2.5

Total storage that would be available for water supply or water quality control at Jackson is approximated by the total of the underlined figures, namely, 16268 Acre feet.

TABLE 6-2

POSSIBLE RESERVOIR SITES
ABOVE LANSING

1 LOCATION	2 STORAGE VOLUME AVAILABLE (Acre-feet)	3 DRAINAGE AREA AT DAM (Square Miles)	4 AVERAGE STREAMFLOW AT DAM (Cubic Feet/Second)	5 AVERAGE ANNUAL STREAMFLOW (Acre-feet)	6 AVAILABLE STREAMFLOW (Acre-feet)	7 RATIO 6/2
Onondaga	<u>221300</u>	569	398	288000	271732	1.2
Spring Brook#2	19000	18	13	9412	<u>9412</u>	0.5
Millet	<u>63700</u>	856	594	430000	183020	2.9
Mud Creek	31600	32	22	<u>15928</u>	<u>15928</u>	0.5
Sycamore Creek	<u>14000</u>	102	71	51400	35472	2.5
Williamston	<u>67200</u>	228	160	115840	115840	1.7
Okemus	<u>23800</u>	306	214	154036	87736	3.7

Approximate storage available for water supply or water quality control at Lansing is given by the sum of the underlined figures plus the storage available at Jackson, namely, 364468 Acre-feet.

The method of treatment considered here for both Jackson and Lansing consists of ammonia oxidation by chemical coagulation and sedimentation using 300 mg/l of hydrated lime and 50 mg/l of ferrous sulfate plus filtration through sand at 4 gallons per minute per square foot plus aeration of the final effluent and pH adjustment before final discharge. This treatment is in addition to conventional secondary treatment.

This degree of treatment should provide an extremely high quality effluent and would be utilized during periods of low stream flow when needed to maintain the required 4 mg/l of dissolved oxygen in the stream.

The alternative of importing water from one of the Great Lakes for augmentation was also considered. In this case a pipeline to Lake Erie capable of augmenting flows in the Grand River below Jackson was evaluated.

Lansing

An average annual discharge of 191 cubic feet per second (cfs) will be required by 1980 and 575 cfs by 2020 is one alternative method of meeting water quality needs below Lansing.

As in the case of Jackson advanced waste treatment was also evaluated as an alternative at Lansing. The unit series of treatment processes considered is the same as at Jackson.

Summary of Alternative Costs

The annual costs of each of the alternative methods of meeting the water supply and water quality problems of the Jackson and Lansing areas of the Grand River Basin are presented in Table 6-3.

Benefits

Implementation of the recommendations contained in this report combined with a judicious selection from the alternatives presented will result in substantial improvement in the quality of the waters of the Grand River Basin.

By their very nature benefits from water quality are diffuse and accrue to all of the citizens within the Basin and are, therefore, difficult to quantify. However, the value of these benefits was implicitly considered in the public hearings which preceded the establishment of intrastate water quality standards by the Michigan Water Resources Commission.

TABLE 6-3
SUMMARY OF ALTERNATIVES
(ALL COSTS IN 1967 DOLLARS)

Type of Problem	Location	Alternative	Year of First Need	Construction Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O&M Cost	Total Annual Cost (Adjusted to 1970)
Water Supply								
	Lansing	Storage Reservoir (46,000 acre feet)	2000	$10,000,000	$2,600,000 (4-5/8%)	$130,000 (50 yrs. at 4-5/8%)	$46,000	$180,000
	Lansing	Pipeline to Lake Mich.	2000	$30,000,000	$7,700,000 (4-5/8%)	$400,000 (50 yrs. at 4-5/8%)	$250,000	$650,000
Water Quality Control								
	Jackson	Advanced Waste Treatment	Present 1995	$1,600,000 $2,200,000	$2,300,000 (4-5/8%)	$120,000 (50 yrs. at 4-5/8%)	$210,000	$330,000
	Jackson	Storage Reservoir	Insufficient Streamflow to Meet Total Requirement					
	Jackson	Pipeline to Lake Erie	Present	$36,000,000	$36,000,000 (4-5/8%)	$1,800,000 (50 yrs. at 4-5/8%)	$3,900,000	$5,700,000

TABLE 6-3 (Continued)
SUMMARY OF ALTERNATIVES
(ALL COSTS IN 1967 DOLLARS)

Type of Problem	Location	Alter-native	Year of First Need	Construc-tion Cost	1970 Present Worth (Interest Rate)	Annual Capital Cost (Assumed Life at Interest Rate)	Annual O&M Cost	Total Annual Cost (Adjusted to 1970)
	Lansing	Storage Reservoir (Williamston 46,000 acre feet	Present	$10,000,000	$10,000,000 (4-5/8%)	$520,000 (50 yrs. at 4-5/8%)	$46,000	$570,000
	Lansing	Storage Reservoirs (Millet, Mud Creek and Okemus) (74,000 acre feet)	1980	$16,200,000	$10,300,000 (4-5/8%)	$530,000 (50 yrs. at 4-5/8%)	$74,000	$600,000
		Storage Reservoir (Onondaga 221,000 acre feet)	2000	$25,000,000	$6,400,000 (4-5/8%)	$330,000 (50 yrs. at 4-5/8%)	$190,000	$520,000
	Lansing	Advanced Waste Treatment	Present 1995	$3,400,000 $5,600,000	$5,200,000 (4-5/8%)	$270,000 (50 yrs. at 4-5/8%)	$160,000	$430,000

It is possible, however, to briefly cite some of the beneficiaries of improved water quality in the Grand River Basin. Owners of property adjacent to or near presently polluted waters will derive increased esthetic enjoyment and enhanced property values from the elimination of the unsightly conditions which result from water pollution. These include nuisance algal blooms stimulated by over-fertilization of the aquatic environment. All the residents of the Basin will benefit from the assurance of a safer, more palatable water supplied to their homes, industries and public buildings.

Michigan residents and visitors from out-of-state who use the area's streams and lakes for swimming, water skiing, boating and other water-oriented recreation will be protected against infectious diseases which can be spread by polluted water. The sport fisherman will find additional fishing areas and improved fishing as a benefit of enhanced water quality. As a return on its investment in clean water, industry will share in the benefits from better quality water for all of its needs.

In addition to these immediate and direct benefits the contribution of a cleaner Grand River to the preservation and protection of the quality of the waters of Lake Michigan is an important benefit and vital to the National welfare.

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HEALTH GUIDELINES

COMPREHENSIVE PLANNING STUDY

OF THE

GRAND RIVER BASIN, MICHIGAN

Prepared by the
U. S. Public Health Service and the
Michigan Department of Public Health

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SECTION I - INTRODUCTION

These health guidelines are for the guidance of those agencies concerned with the development of water resources of the Grand River Basin. The guidelines are not intended to be used as a comprehensive design document. Rather, they are intended to provide a basic document which points out those areas which require special attention by planning authorities.

State law requires that every county in Michigan operate a county health department. These county health departments are provided with guidance and technical assistance and their operations are supplemented by the Michigan Department of Public Health. Consultation with these public health authorities will insure the inclusion of adequate public health protection and improvement in water resource development plans.

Federal agencies active in water resources development such as the Corps of Engineers and the Soil Conservation Service are required to obtain review of proposed projects from other interested Federal agencies including the Public Health Service.

This document includes a brief review of the activities of county and State health authorities in the subjects of concern and a discussion of the health factors considered by the Public Health Service in its review of Federally sponsored water resource development projects for the Grand River Basin.

The subjects of concern discussed herein include public drinking water supply, recreation area development, solid waste management, vector control, irrigation and radiological health.

SECTION II - PUBLIC DRINKING WATER SUPPLY

1. GENERAL: Reference to public drinking water supply is defined in this document as those water supplies developed for domestic and food processing uses. Public water supplies in the State of Michigan are designed, constructed and operated under the jurisdiction of the Michigan Department of Public Health by authority of Act 98, P.A. 1913 as amended and associated rules and regulations.

2. EXISTING SUPPLIES: Determination of the exact number of water supplies in the basin is difficult because several communities are only partially within the Grand River Basin. There are, however, about 50 ground water supplies and five complete water treatment plants using surface water which serve the population of the Basin. The surface water supplies serve ten communities. Only one of the treatment plants is a full time facility using river water as a source. Three of the treatment plants use Lake Michigan water and are not located within the Basin. The remaining facility treats river water but is operated only on a part-time or emergency basis as a backup for a Lake Michigan filtration plant.

3. GROUND WATER QUALITY AND QUANITY: Properly installed and developed wells within the basin generally will provide water of satisfactory bacteriologic and chemical quality. Corrective treatment is provided in some cases for iron, hardness, and hydrogen sulfide problems. Continuous chlorination of the larger ground water supplies is accepted practice. In the small areas where groundwater problems do exist, surface water supplies are available. Water bearing formations in this basin can be developed in either rock or drift, and the well production will vary greatly. Most areas in the interior portion of the state can develop adequate ground-water supplies for the present. Growth within the next 20 years, however, may make it necessary to augment the ground water supplies of certain cities with surface sources.

4. SURFACE WATER QUALITY AND QUANTITY: While the quality of the Grand River and its tributary waters is variable and not considered the best for drinking water supplies, it is satisfactory for use with full treatment. Lake Michigan waters are accessible for use in the Grand River Basin and are known to be of good quality. The Michigan Department of Public Health requires full treatment of the surface waters available to the Grand Basin. Full treatment includes a minimum treatment equivalent to coagulation, sedimentation, filtration and chlorination. The quality and quantity of the drinking water produced must meet or exceed accepted standards. To insure that this is done the State requires supervision of all water treatment plants by a certified operator.

5. HEALTH FACTORS CONSIDERED BY THE PUBLIC HEALTH SERVICE

5.1 General: Where water supply for public drinking water use is included in Federally sponsored projects, appraisal of the origin, determination of available water quality, and determination of necessary treatment should be included as part of the project study as well as determination of availability of water quantity. Lack of this preliminary information in a work plan constitutes inadequate appraisal of the water supply benefit and makes appraisal of the expected health benefit a matter of supposition. Raw water supplies offered to and accepted by local purveyors with no determination of potential hazards and necessary treatment for existing and potential quality is analogous to the purchase of consumer goods of questionable quality with no guarantee for return. If the project supply is unfit for the intended water supply use, the project may become a liability to the national as well as the local economy.

5.2 Appraisal of Origin: The appraisal of the origin is usually accomplished by a sanitary survey of the site and appraisal of both human and animal activity expected to occur within the watershed area of the site. Persons trained and competent in public health engineering and the epidemiology of waterborne diseases should conduct the sanitary survey. The sanitary survey should include the detection of health hazards including all significant sources of pollution and the assessment of their present and future importance.

The appraisal of the origin together with the determination of available and expected future quality will be important to the determination of the suitability of the water for the intended use and will also be important to the determination of suitable treatment.

Information which should be determined includes:

1. Ownership and proposed ownership of the reservoir's watershed, particularly lands adjacent to the reservoir.

2. Major sources of natural pollution including large populations of animals; drainage from mineral deposits, swamps or bogs; and surface run-off characteristics.

3. Major sources of man made pollution including mine drainage, unsewered residential areas, run-off from construction, residential, commercial, and industrial areas, sewer drainage, sewage treatment plant effluent, and animal feed lots.

4. Present and expected activity on the watershed including type and degree.

5. Zoning or restrictions to be placed on activity within the watershed.

5.3 Determination of Available Water Quality: A reliable determination of available water quality will normally be very difficult due to variable conditions affecting water quality of the stream, lack of past water quality data, and uncertainty regarding the degree of improvement which will probably occur with impoundment.

Where past water quality data exists, the known bacterial, chemical, physical, and radiochemical characteristics should be evaluated with reference to the Public Health Service Health Guidelines for Raw Water Quality and applicable State Water Quality Standards. The data should, of course, consist of samples taken at such frequency and of such variety as to properly describe the body of water's quality. Evaluation of such data should also be conducted in full cognizance of sanitary survey findings. Adverse action on data exceeding the recommended Health Guidelines and the applicable State Standards should depend upon the degree which the guidelines or standards are exceeded, the availability of other supplies, expected changes in water quality, and the treatment which can be provided.

If no water quality data exists for the mandatory chemicals (i.e. those included in the mandatory PHS Drinking Water Standards), turbidity, coliform (fecal or total) and total dissolved solids, grab samples representative of different stream conditions should be taken and analyzed for these constituents by methods described in Standard Methods for the Examination of Water and Waste Water.

Past studies have indicated that, in most cases, bacterial and physical quality improve as water passes through an impoundment. Marginal bacterial, and physical quality can, therefore, be expected to improve unless polluted populated areas, large swamps, uncleared heavily wooded areas or other major sources of organic material are to be flooded or created on the reservoir's margin. The water intakes should be located on the reservoir where maximum advantage can be taken of the improvement in quality effected by impoundment. The intakes should also be of multilevel construction so that the best quality of water at the intake can be drawn into the supply system.

5.4 Determination of Necessary Treatment: The determination of necessary treatment is important to the individual project because such a determination will indicate the capital cost required to develop the supply and may affect the local sponsor's willingness to underwrite the water supply costs and benefits proposed for the project.

The following text describes the water quality considered adequate by the Public Health Service for no treatment and conventional treatment. Treatment can be varied and special processes can be applied to solve special problems which cannot be resolved by conventional treatment. If water resource development causes a problem for existing public water supplies, such as increases in color, iron, manganese, etc., the additional cost to solve the problem should be considered a negative benefit.

a. Untreated Water: Only underground waters not subject to potential contamination and meeting the water quality guidelines specified below as shown by satisfactory, regular and frequent sanitary inspections and laboratory tests are considered safe with no treatment. The continuous safety of untreated public drinking water supplies is questionable due to the hazard presented to such supplies by their distribution systems. It is, therefore, recommended that all public drinking water supplies receive at least residual disinfection treatment.

The raw water quality* considered satisfactory by the Public Health Service for a supply receiving no treatment is:

a) Bacteriological: Should meet Public Health Service Drinking Water Standards.
b) Physical: Should meet Public Health Service Drinking Water Standards.
c) Chemical: Chemicals present should not exceed the following concentrations.

Substance	Concentration (mg/l)
Arsenic (As)	0.01
Barium (Ba)	1.0
Boron (B)	1.0
Cadmium (Cd)	0.01
Carbon Chloroform Extract (CCE)	0.2
Chloride (Cl)	250.0
Chromium (hexavalent, Cr^{6})	0.05
Copper (Cu)	1.0
Cyanide (CN)	0.01
Detergents (Methylene Blue Active Substances)	0.5
Fluoride (F)	1.8
Iron (Fe)	0.3
Lead (Pb)	0.05
Manganese (Mn)	0.05
Nitrogen (In nitrate or nitrite form)	10.0
Phenols	0.001
Selenium (Se)	0.01
Silver (Ag)	0.05
Sulfate (SO_4)	250.0
Total Dissolved Solids	500.0
Uranyl ion (UO_2)	5.0
Zinc (Zn)	5.0

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*The quality guidelines should not be exceeded over substantial periods of time. If they are exceeded, efforts should be made to determine the cause and corrective action should be taken. If corrective action fails to improve the water quality to within the guidelines, the water quality should be judged unsatisfactory.

d) Radioactivity: Should meet Public Health Service Drinking Water Standards.

e) Pesticides: Should not exceed the following limits:

	Pesticide	Long Term Exposure Maximum Permissible Concentration mg/l
1.	Endrin	0.001
2.	Aldrin	0.017
3.	Dieldrin	0.017
4.	Lindane	0.056
5.	Toxaphene	0.005
6.	Heptachlor	0.018
7.	Heptachlor Epoxide	0.018
8.	DDT	0.042
9.	Chlordane	0.003
10.	Methoxychlor	0.035
11.	Total Organophosphorous and Carbamate Compounds (expressed in terms of Parathion Equivalent Cholinesterase inhibitions)	0.1
12.	2,4,5-TP	Individual limits = 0.1 mg/l. Sum of any combination of chlorinated phenoxy alkyl pesticides-0.1 mg/l. Short periods only. Two to three days, no more than once or twice a year.
13.	2,4,5-T	
14.	2,4-D	

Substances not included in the above table which may have deleterious physiological effect or which may be excessively corrosive to the public drinking water supply system should not be permitted in the raw water supply if such substances cannot be removed by available treatment.

b. Conventional Treatment: All surface waters utilized for public water supply in the Grand River Basin should receive a minimum of conventional treatment including coagulation, sedimentation, rapid sand filtration, and pre and post disinfection or equivalent treatment. Although it may be impossible to prevent all pollution from entering the supply, such entrance should be controlled and limited. If recreational use of terminal reservoirs is permitted, the recreational use should be controlled and policed with such use prohibited on and near the public drinking water supply intake. With the time of storage an important factor, consideration should be given to the location of the intake with respect to the reservoir's bottom, surface-drainage inlets, and recreation areas. The design and construction of individual water treatment plants will vary with local circumstances and should be based on results of experiments on the water to be treated.

Conventional treatment as defined above will normally produce safe water of desirable characteristics if the State water quality standards are met and if the following guidelines are not exceeded in the raw water quality*:

a) Bacteriological:
   1) Total Coliform Density: Less than 20,000/100 ml. as measured by a monthly geometric mean or,
   2) Fecal Coliform Density: If fecal coliform density is measured, the above total coliform density may be exceeded but fecal coliform should not exceed 4,000/100 ml. as measured by a monthly geometric mean.

b) Physical: Elements of Color, Odor, and Turbidity contribute significantly to the treatability and potability of the water

Color - - - - - - - - - - - - - - 75 units

(This limit applies only to non-industrial sources, industrial concentrations of color should be handled on a case-by-case basis and should not exceed levels which are treatable by complete conventional means.)

Threshold Odor Number - - - - 5 units
Turbidity - - - - - - - - - - - Variable

(Factors of nature, size, and electrical charge for the different particles causing turbidity require a variable limit. Turbidity should remain within a range which is readily treatable by complete conventional means; it should not overload the water treatment works; and it should not change rapidly either in nature or in concentration where such rapid shifts would upset normal treatment operations.)

c) Chemical:
   1) Since complete conventional treatment generally produces little reduction in chemical constituents, raw water should meet the limits given for untreated raw ground water.

d) Radioactivity: Should meet Public Health Service Drinking Water Standards.

e) Pesticides: Should meet requirements for Pesticides as shown for untreated raw ground water.

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*The quality guidelines should not be exceeded over substantial periods of time. If they are exceeded, efforts should be made to determine the causes and corrective action should be taken. If corrective action fails to improve the water quality to within the guidelines, the water quality should be judged unsatisfactory.

Water of poorer quality should receive auxilliary treatment as determined by the user's engineer or consultant and should only be used if no raw water supply of better quality is available and if mandatory limits of the Public Health Service Drinking Water Standards are not exceeded in the treated water. For more detailed information regarding the evaluation of public drinking water supplies, the Public Health Service "Manual of Drinking Water Supply Evaluation" may be consulted.

SECTION III - RECREATION AREA DEVELOPMENT

1. GENERAL: This guideline has been prepared for the use of planners and others interested in water and related land use development. It is intended to serve as an introduction to the factors of concern to health authorities in the development of recreation areas. Winter sports are not considered. The format and much of the text of the Guideline were taken from "Environmental Health Practice in Recreational Areas." The material included in this guideline was developed through the cooperation of the Michigan Department of Public Health and the Public Health Service. Reference to applicable local and State law and rules and regulations is made where appropriate in each topic discussion.

In many instances the planning, provision and maintenance of facilities in recreation areas have not kept pace with the rapidly increasing visitor load. As a result optimum use of such areas is not possible and deterioration of overtaxed facilities is frequently encountered. Where facilities such as water supply, sewage disposal, and refuse handling are inadequate or lacking, the visitors will fend for themselves, often creating conditions which are aesthetically offensive and which present serious environmental health hazards to the visitors and neighboring community residents. Recreation needs are expected to increase by a factor of four by the year 2000 due to population increases and increased leisure time. More important those activities which require greater capital investment in sanitation facilities and services such as camping are expected to increase even more. In the Grand Basin today the demand generally exceeds the supply for recreational use by a factor of 2. Estimates are that adequate environmental health safeguards comprise approximately 30 percent of development costs of new recreation areas. Since these safeguards represent such an appreciable investment care should be taken in properly planning, constructing and maintaining adequate facilities.

The most effective means to insure adequate consideration of factors influencing the public health is by active cooperation between health and recreation agencies. The public health surveillance of recreation facility development and maintenance is normally carried out by the county health departments in Michigan with technical assistance provided by the State Department of Public Health. County health departments have been established in every county of Michigan. Table 1 summarizes the subjects covered by the county health department regulations for each county.

A field evaluation of a proposed site and the review of plans for site development and construction of buildings and facilities should be made by the health department having jurisdiction. Following construction a program of periodic surveys and inspection of facilities

TABLE 1 LOCAL HEALTH DEPARTMENT REGULATION

County or District Health Department	Regulations									
	Food Establishment	Food Handling	Garbage and Refuse Disposal	Habitable Buildings and Dwellings	Land Subdivision	Sewage Disposal	Solid Waste	Water Supplies	Resorts	Others
Barry-Eaton District	X		X			X		X		X*
Ingham	X					X				
Ionia	X			X		X		X		
Jackson	X		X	X	X	X				
Kent	X			X		X		X		
Mid Michigan District (Clinton, Gratiot, Montcalm)	X		X			X		X		
Ottawa						X				
Shiawassee	Information not available									

*Nuisance Code

and their operation in recreation areas should be established by public health and recreation authorities. It is recognized that the development of remote areas, wilderness areas, and low-density use areas will not include complete modern sanitary facilities but in many cases will provide primitive or minimum sanitary facilities.

2. SITE SELECTION: Sites selected for recreation areas should be well drained and free from topographical or geological hindrances. The terrain should be suitable for the recreational purpose for which the area is designed without hazardous elevation changes. If no onsite development of water supply and sewage disposal works is planned, the area should be accessible to proposed sources of water supply and sewage disposal. Sites should be free from heavy traffic, air pollution sources, and noise sources. Avoiding locations near swamps and marshes, where insects such as mosquitoes may breed and cause severe annoyance and discomfort, will significantly enhance enjoyment and utilization of the area by the visiting public.

Other considerations of importance are:
1) Availability of adequate good quality ground water where no offsite source of drinking water is accessible.
2) Adequacy of the site's characteristics for the proposed method of sewage disposal.
3) Potential of the area for vector breeding with special attention to swamps and drainage.
4) Upstream sources of pollution particularly where bathing beach development is proposed.
5) Safety hazards such as dead trees, power lines, gravel pits, railroads, etc.
6) Hazards to the entrance to and exit from the recreation area.
7) Preclusion of flooding of proposed sanitary facilities.
8) Control of undergrowth and noxious weeds in developed areas.

3. WATER SUPPLY: Water supplies for recreation areas are governed by the Michigan Department of Public Health "Regulations for Certain Water Supplies in Michigan". Provision of a supply of adequate quantity and quality is essential for the convenience, comfort, safety and health of visitors and resident staffs at outdoor recreation areas. Points which should be considered are:
1) Extension to the recreation area of any State approved public water supply within a reasonable distance.
2) Surface supplies are not approved generally for recreational areas except where they are a part of a municipal supply.
3) Design, construction, and supervision of the proposed water system to minimize potential vandalism.
4) Protection of the water quality through the design, construction, and maintenance of the distribution system.

5) Provision for fire protection.
6) Isolation of well sites from sources of pollution and areas of expected human use.

4. SEWAGE DISPOSAL: Safe disposal of human and domestic wastes in recreation areas is necessary for the preservation of the surface and ground waters and the restoration of such waters to the best possible condition consistent with the public health and welfare. Proper sewage disposal prevents damage caused by sewage to the propagation and preservation of fish and wildlife, and is essential to protect the visiting public, employees, and nearby communities from diseases transmitted through sewage. Three types of sewage disposal systems are recognized as applicable for use in recreation areas. These are privies of various types regulated by "Privy Law and Regulations," septic tank systems, and package treatment plants.

Some important health related factors are:
1) Provision of a properly designed, constructed, and supervised water-carriage sewage-disposal system where possible. Experience has shown that pit toilets for recreation areas have been unsatisfactory in many cases.
2) Locating outfalls to minimize the potential effects of effluent sewage.
3) Proximity of septic tank and subsurface disposal systems to buildings, beaches, camping and picnic areas, and water supply systems.
4) Properly planned sludge disposal.
5) Provision for adequate protection of the ground and surface water and for adequate operation and maintenance.

5. PLUMBING: Plumbing includes "the practice, materials, and fixtures used in the installation, maintenance, extension, and alterations of all piping, fixtures, appliances, and appurtenances in connection with any of the following: sanitary drainage or storm drainage facilities, the venting system, and the public or private water supply systems within or adjacent to any building structure, or conveyance; also the practice and materials used in the installation, maintenance, extension, or alteration of storm water, liquid waste, or sewage, and water supply systems of any premises to their connection with the public sewer system or other acceptable disposal facility."

In planning the following should be considered:
1) Provision of at least a minimum number of plumbing fixtures based upon peak visitor day use (see Table 2).
2) Conformance of materials used and installation to the Michigan State Plumbing codes.

6. BUILDING AND HOUSING HYGIENE: Housing of a healthful quality must provide for fulfillment of the physiological needs of man, which include: a thermal environment that not only is conducive to good

TABLE 2

Sanitary Facilities[a] for Recreation Areas

		Water Closets	Urinals	Lavatories[c]	Showers
Swimming pools[b] (Based on maximum load, Fixtures/bathers)		1/75 males 1/50 females	1/75 males	2/200	1/50 minimum of two
Campground Comfort Station	Camping Sites				
	1-20	1 male 2 female	1	2	d
	21-30	2 male 3 female	2	4	
Picnic Area Comfort Station	Parking Spaces				
	1-40	1 male 2 female	1	2	
	41-80	2 male 4 female	2	4	
	81-120	3 male 6 female	3	6	

Each comfort station should be designed to provide service for sites no further than 500 feet away.

a Provisions for the handicapped should be provided.
b One drinking fountain not installed in toilet room should be provided.
c Divided evenly between male and female restrooms.
d Campgrounds at which visitors may be expected to stay for periods greater than two days should include showers in the comfort station facilities.

health but is comfortable and promotes efficiency of living; air that is chemically pure and free from objectionable odors; humidity that is healthful and comfortable; and air movement that will assist in maintaining the desired thermal conditions and air purity and will provide for necessary air changes. Housing should be free of noise that may impair health. Lighting should be quantitatively and qualitatively adequate including both natural and artificial sources. All buildings and dwelling units should be constructed and maintained in accordance with the minimum requirements set forth in the APHA-PHS Recommended Housing, Maintenance and Occupancy Ordinance or requirements that are substantially equivalent. The "Basic Principles of Healthful Housing" is another good reference in the field of housing. Those concerned with the design, operation, and maintenance of public buildings should consult these references for more complete coverage of this subject. Plans and specifications covering housing, dormitories, camps, hotels, restaurants, and similar facilities should be submitted to the appropriate authorities having jurisdiction for review and recommendations. Some of the more important aspects of housing not covered elsewhere in this Guideline are:

1) Provision of adequate openable window area for habitable rooms.
2) Provision of adequate outlets and electrical fixtures where electric service is available. Installation of electrical service in accordance with the State Electrical Code.
3) Provision of adequate safe heating facilities.
4) Provision of screens for doors and openable windows during seasons when it is necessary to protect against mosquitoes, flies, and other insects.
5) Protection of buildings against rodent entry.
6) Construction of water closet compartment and bathroom floor surfaces of material impervious to water.

7. FOOD SANITATION: Despite the progress which has been achieved in food protection programs, foodborne illness continues to be a major public health problem. The incidence of such illness can be reduced by the application of the basic principles of food protection. To achieve this on a day-to-day basis, however, better understanding on the part of many food-service employees and employers must be developed, and this in turn will necessitate a maximum of cooperation between public health agencies and the food service industry. The need for even greater attention to this problem in recreation areas is due to the seasonal operation of many areas and the widely fluctuating visitor load that must be accommodated by food service facilities provided. Seasonal employees who lack adequate training in good food-handling practices introduce additional hazards. Control of food sanitation for food prepared and served on the premises is attained by adherence to the Michigan Food Law.

8. SOLID WASTE DISPOSAL: Solid waste disposal in Michigan is controlled by Act 87. Public health problems are often associated with improper storage, collection, and disposal of solid waste in

recreation areas. Experience has shown that the application of the basic principles of sanitation to solid waste handling results in substantial reductions in fly, rodent, and other insect problems. In addition, there are significant relationships between the incidence of certain diseases in humans and animals and improper solid waste disposal. Many hazards and nuisances, such as fire, smoke, odors, and unsightliness, are also created by poor solid waste handling practices. The full appreciation of recreation area values by the public is often diminished by the disorder of accumulated solid waste.

Among the principles to be planned for are:
1) Collection of solid waste in durable, watertight, rust-resistant, nonabsorbent, and easily washable covered containers.
2) Sufficient solid waste management program (number of containers, size of containers, and frequency of collection) to prevent unsightliness and fly and rodent problems.
3) Disposal of trash and garbage.
   a. by sanitary landfill
   b. by approved auxilliary fuel incineration
   c. by garbage grinding (to sewage system)
   d. by modified sanitary landfill where no hazard to public health may occur.
4) Prohibition of open burning other than camp fires.

9. <u>WATER CONTACT RECREATION WATER QUALITY</u>: Limited biological, chemical, and physical quality guidelines are outlined below. Where questions arise regarding the health aspects of water quality, county and State health authorities should be consulted. Reference should also be made to State Water Quality Standards and the water pollution control authorities responsible for the administration of such standards. Final judgment on the acceptability of the use of any water classified under these guidelines should also include consideration of the significance of the findings of a complete sanitary survey and continuous surveillance of possible hazards based on epidemiological data as well as appropriate safety considerations.

<u>Biological</u>

The fecal coliform density should not exceed a geometric mean of 200/100 ml with a sampling frequency of 5 samples per 30-day period taken during peak recreational use. Not more than 10 percent of the samples fecal coliform densities during any 30-day period should exceed 400/100 ml.

<u>Chemical</u>

The water should contain no chemical which could cause toxic reaction if ingested or irritation to the skin or eyes. The water's pH should be within the range 6.5-8.3

Physical

The water's color should not exceed 15 standard units and its turbidity should not exceed 30 standard units. Maximum water temperatures should not exceed 85°F (30°C).

10. SWIMMING POOLS AND BATHING BEACHES: Public Health authorities have been concerned with sanitation and safety problems involving swimming pools and bathing beaches for many years. While the problem of accidents and drownings are the most dramatic statistics relating to swimming, the communicable disease aspects must be given proper attention. These facilities must meet the provisions of the Michigan Public Swimming Pool Law and the Michigan Public Bathing Beach Law.

The following factors should be considered:
1) Design, construction, and operation of proposed swimming pools in accordance with requirements of State Law and county health regulations.
2) Acceptability to health authorities of the proposed water supply as a potable water source.
3) Provision of adequate numbers of lifeguards.
4) Discharge of the swimming pool water through an air gap to the waste water receiver and recharge of the swimming pool through an air gap.
5) Proper design for "use loading".
6) Practice of continuous disinfection of pool water.
7) Routine examination of bacteriological samples.
8) Decisions on the use of natural bathing areas based upon site evaluation and the results of chemical analyses, bacteriological examinations, and a sanitary survey of the proposed natural bathing area.
9) Elimination of possible gross animal pollution of the bathing area.
10) Evaluation of the effects of peak visitor days on water quality and recreational use.
11) Availability of shower and toilet facilities.

11. TRAVEL TRAILER PARKING AREAS: The great increase in the number of travel trailers on the highways during the vacationing months is quite evident to the motoring public and reflects the increasing amount of leisure time and extra spending power being enjoyed by more people each year. It also points out the need to keep pace by the development of adequate travel trailer parking areas and related facilities each year which meet standards of health and safety. Trailer parks are regulated by the Michigan Trailer Park Law.

Considerations involving standards of health and safety are:

1) Design of parking facilities for both self-contained and non self-contained travel trailers.

2) Provision of sanitary facilities for the disposal of holding tank wastes and for the refilling of water supply holding tanks.
3) Design of travel trailer parking areas for overnight or destination use.
4) Availability of adequate water supply and satisfactory means of sewage disposal.
5) Design of approach roads for trailer traffic.
6) Conformance of the spacing of trailers to the minimum 15 foot separation specified by the National Fire Protection Association.
7) Remoteness of water tank filling stations from liquid waste disposal stations.
8) Special provisions for the disposal of sink wastes.
9) Development of detailed plans for refuse disposal.
10) Convenience and adequacy of service buildings for anticipated use.
11) Provision of electrical service by underground cable.
12) Submission of detailed plans and specifications of the travel trailer parking areas to the health authority having jurisdiction for review and approval.

12. BOATING: The Bureau of Outdoor Recreation has estimated that boating will increase from 1800 occasions in 1960 to over 7500 occasions by 2000. Many of the boats used are being equipped with a galley and toilet facility. Body wastes, galley wastes, and other debris are therefore being discharged into watercourses threatening to damage the recreational values of swimming, fishing, and other aquatic sports. The dredging of boat basins and the construction of small craft harbors, marinas, boat launching ramps, and docking floats are but a few of the projects being constructed or planned for recreation areas. Such new developments which attract and serve boating enthusiasts may create water pollution and related health problems of concern to public health and recreation authorities. For this reason it is most important that the planning of such developments consider the environmental health aspects involved such as:
1) Inclusion of adequate separate facilities for collection and disposal of sewage, waste oils and fuel, and solid wastes accumulated on boats in the planning and design of proposed marines.
2) Location of a permanent comfort station with sanitary facilities for each sex near the piers.
3) Provision of a water-carriage sewage-disposal system including adequate treatment.
4) Provision of land disposal of wastes from floating facilities.
5) Provisions to eliminate waste and spillage during storage and dispensing of gasoline from floating facilities.
6) Regulation of construction and use of boats with marine toilets.
7) Inclusion of refuse disposal practice, designation of restricted areas, safety requirements as recommended by the U. S. Coast Guard, and the control of health and accident hazards in boating requirements.
8) Full separation of boating and swimming areas.
9) Adequate docking facilities for boats and parking facilities for cars.

13. FISHCLEANING FACILITIES: Fishing is an activity many visitors enjoy while visiting recreation areas, especially where natural reproduction and stocking of local waters is accomplished. Where fishing is productive, consideration should be given to the installation of fish-cleaning facilities near boat docking and launching areas. These facilities are essential to control nuisances, odor, and pollution from the indiscriminate cleaning of fish and the disposal of the resulting wastes into lakes, reservoirs, and along shorelines.

In planning these facilities consideration should be given to the following factors:
1) Screening or full inclosure of the facility.
2) Provision of tables having impervious, nonabsorbent surfaces sloping to central drains or of adequately maintained wood tables.
3) Provision of potable water under pressure.
4) Provision of adequate disposal of collected wastes and maintenance of the facility in a clean condition.

14. INSECT AND RODENT CONTROL: Several groups of anthropods and rodents may create serious public health and nuisance problems at recreation areas. These include species that are vectors of human disease organisms or which serve as reservoirs of these organisms or otherwise interfere with man's health, welfare, and comfort. A number of aquatic insects may be encountered at recreation areas located along the shore of impoundments. Mosquitos are undoubtedly the most important of these insects, since several species serve as vectors of encephalitis and malaria, and others create public health problems because of their vicious biting habits. Other groups of aquatic insects such as deer flies, horseflies, black flies, and biting midges are vicious biters of man and sometimes are involved in transmission of disease. In addition to the aquatic insects, people who visit water-related and other recreation areas are often exposed to terrestrial arthropods such as ticks, mites, fleas and flies, and rodents including ground squirrels, rats and mice. Irritation, discomfort, and annoyance caused by bites of insects can seriously reduce the use of an otherwise attractive recreation area. Thus it becomes most important that measures be taken to eliminate or reduce such insect populations.

State health agencies should be asked for pre-construction surveys and technical assistance in preparing control programs based on the following principles:
1) Delineation of mosquito production sites.
2) Implementation of mosquito control practices in preparation of the reservoir basin prior to impoundage.
3) Utilization of naturalistic and source reduction measures.
4) Planning for maintenance practices to control mosquito production within flight range of recreational and inhabited areas.
Health agencies will also provide technical information concerning:
1) Steps to be taken to control terrestrial arthropods and rodents.

2) Hazards to humans and animals posed by proposed chemical control measures against insects and rodents.
See also Section IV - Vector Control for additional information.

15. CAMPGROUNDS, PLAYGROUNDS, AND PICNIC AREAS: Camping is often a necessary part of any outdoor recreation outing that extends beyond one day. Many vacationers stay in motels and hotels; however, tents, travel trailers, and pickup campers have loomed larger and larger on the camping scene in recent years. Camping in the 1960's is increasing at a faster rate than the provision of sites and facilities for camping. It is estimated that by the year 2000 camping demands will exceed present supply by a factor of 10. Camping facilitates other outdoor activities, such as boating, fishing, hunting and hiking. When resources are developed for such purposes, adequate facilities for camping also should be provided. A survey of participation in outdoor recreation conducted in 1959 and 1960 showed that about one-third of the campers enjoy camping in remote areas removed from other people, while about the same proportion enjoy camping in an area where they can visit with other campers. Consequently both types of camping areas are needed, with proper consideration given for environmental health factors relating to this mode of recreation.

Some factors of importance are:
1) Provision of level well-drained tent areas.
2) Plans for regular maintanance of the grounds (removal of poisonous plants, hazards, and vector harborages).
3) Remoteness of playgrounds from traffic areas, hazardous topographic features and hazardous land uses.
4) Convenient location of a water supply and comfort station in the area.
5) Location of camping units on one-way loop roads or cul-de-sacs.

16. CONCLUSION: Applicable laws and regulations applied by the Michigan Department of Public Health not previously referred to include:
1) Sanitation Standards for Recreation Camps D-46
2) Department of Social Services Rules for Licensing Summer Camps - R 400.231 thru 400.238
3) Sanitation Standards for Resorts and Tourist Accomodations D-44
4) Subdivision Control Act (Act 288, PA 1967)
5) Licensing of Agricultural Labor Camps (Act 289, PA 1965)

SECTION IV SOLID WASTE MANAGEMENT

1. GENERAL: The disposal of industrial, commercial, and domestic solid wastes has become a growing, monumental problem. The cost restrictive limitations placed on refuse disposal are those imposed in the interests of public health and environmental control. The term "public health" is interpreted broadly with regard to refuse storage, collection, and disposal. It refers not only to the direct transmission of pathogenic disease to man and animals and the reservoirs from which disease may emerge, but also to such factors as smoke, odor, dust, fly ash, water pollution, noise, and unsightly appearance which degrade the environment.

Proper solid waste management will improve the safety and quality of the environment:
1) By eliminating harborage and food supply for rats, flies, mosquitoes, and other disease vectors or nuisances.
2) By controlling air pollution through the elimination of open burning or, in the case of incineration, more efficient combustion. Odors, fly ash, and smoke are controlled through proper combustion control design and operation.
3) By eliminating surface and ground water pollution associated with improperly disposed refuse.
4) By reducing fire hazards associated with improperly stored refuse and through the elimination of open burning or dumping of refuse.
5) By making solid waste disposal mechanisms aesthetically acceptable.

Solid waste management and its potential effects should be considered in water resources development projects, particularly where recreation and water quality are of importance. The problems of harborage and food supply for insect and animal disease vectors or nuisances, surface and ground water pollutions, fire hazards, and aesthetic insult often result from improper storage or disposal of refuse.

2. CONTROL OF SOLID WASTE MANAGEMENT: In Michigan the Department of Public Health, the Department of Natural Resources and certain local Health Departments share responsibility for the control of solid waste management.

2.1 Department of Public Health: Act 87, P.A. 1965, Solid Waste Disposal Area Licensing provides that authorized health authorities must regulate garbage and refuse disposal through:
1) Site review of proposed disposal areas
2) Plan review of proposed disposal facilities
3) Required application and bonding for licensing
4) Routine inspection of operating facilities
5) Final inspection of disposal areas to be closed

Act 348, P.A. 1965, Air Pollution Control requires the Department of Public Health to administer the rules of the Air Pollution Control

Commission. These rules include:
1) Investigation of the emission loadings on the atmosphere of any fuel burning operation.
2) Review of plans and issuance of permits for the construction of incinerators.
3) Investigation of nuisance conditions created by open burning.

The Department also provides consultation on insect and rodent control and solid waste management planning whenever possible.

2.2 Department of Natural Resources: Act 291, P.A. 1965, Use of Flood Plains requires that the use of submerged lands adjoining any of the waters of the State be reviewed by the Department of Natural Resources and that a permit authorizing such use be obtained. Act 167, P.A. 1968, Flood Plain Control further requires that the use of areas subjected to flooding along the waters of the State be reviewed by the Department. Approval of the Water Resources Commission is required prior to use.

Act 136, P.A. 1969, Liquid Waste Haulers License requires such haulers to obtain a business and vehicle license and to obtain approval of proposed disposal areas from the Department.

2.3 Other Authorities: None of the county health departments in the Grand River Basin have local regulations controlling solid waste disposal. County health authorities act as agents of the Department of Public Health, however, and are important in the implementation of Act 87. Other State enabling acts important to solid waste management are: Act 179, P.A. 1947; Act 185 P.A. 1947; Act 342, P.A. 1948; Act 1, P.A. 1967; and Act 320, P.A. 1927.

3. SOLID WASTE MANAGEMENT

3.1 Accumulation and Storage: Solid waste management begins with the provision of an efficient mechanism for the storage of the waste generated by individuals and organizations at the sites of interest. Normally such a mechanism is simply the provision of insect and rodent proof containers of sufficient volume to hold the maximum amount of waste generated between collections without overflowing. Possible mechanization should be considered.

3.2 Collection: Following the orderly accumulation of waste in adequate containers as described above, the waste must be removed before putrescible materials cause odor problems. There normally must be at least twice a week collection in the temperate climate of the United States. Where public use varies greatly such as for recreational areas, collections may be required daily during periods of heavy use such as vacation periods, holidays, and weekends.

3.3 Disposal: After accumulation and collection (including transportation in covered vehicles) disposal of the waste must be accomplished. With the large amounts of waste often collected the small problems of

individual accumulation sites become large problems at the disposal site with the added problem of various forms of air pollution where burning occurs.

Adequate disposal may be defined as occurring where no nuisance or hazard to health is incurred by the means of disposal used. Therefore, adequate disposal may vary from open dumping in areas approved by the health agency having jurisdiction to the sanitary landfill or incineration with air pollution controls required for populated areas. For further consideration of the modern practices associated with the sanitary landfill and incineration means of solid waste disposal, reference is made to those local and State health agencies having jurisdiction as discussed above.

4. RECREATION AREAS: Recreation areas and the supporting economy that often develops around such areas may be expected to generate significant amounts of refuse material. Basic principles of solid waste management for recreation areas are discussed in Section III of this guideline.

5. RESERVOIR PLANNING: Before impoundment, a survey should be made to locate solid and liquid waste disposal sites that will be inundated. This survey should be part of a general assessment of pollution sources, levels, and potential. If it is determined that these sites could cause a significant pollution problem, the objectionable material should be removed.

The filling of a reservoir represents a change in hydrologic conditions which will raise the nearby groundwater table. If the higher groundwater table intrudes upon a solid waste landfill or sewage disposal facility pollution could result. Further investigation and corrective and or protective measures should be taken accordingly.

SECTION V VECTOR CONTROL

1. GENERAL: These guidelines should assist in the evaluation of insect and rodent control problems and in the prevention and control of disease vectors and pests which may be associated with water and related land resources.

The guidelines are broken down into two categories:
1) Practices for the Prevention and Control of Vector Problems
2) Field Survey and Epidemiological Surveillance

Major vectors considered include mosquitoes from the water resource and flies, ticks, and rodents from the related land resource.

The major diseases transmitted by mosquitoes are malaria, yellow fever, dengue, encephalitis, and filariasis. Control programs and climate have now reduced malaria, yellow fever, dengue, and filariasis to minor or historical importance in the United States. St. Louis and Western encephalitis have only occurred in isolated cases in Michigan. Thus, mosquitos in Michigan are only considered as nuisances which can cause severe discomfort and secondary infections particularly when present in large numbers.

At present, ticks are known to transmit five groups of deadly diseases: rickettsial, such as spotted fever; bacterial, such as tularemia; spirochetal, such as relapsing fevers; viral, such as Colorado tick fever, and protozoal, such as Texas cattle fever. They also produce a toxic paralysis. Tick transmitted diseases have occurred primarily in the South Atlantic, Appalachian, and Western states. The incidence of such diseases in Michigan is very low. Since ticks are so widespread, however, the hazard from them should be considered omnipresent.

2. PRACTICES FOR THE PREVENTION AND CONTROL OF VECTOR PROBLEMS: In the prevention and control of vector problems, special emphasis must be placed upon the prevention of physical conditions which may result in increased vector populations and upon the establishment of physical conditions which will minimize or eliminate existing vector problems; attention must also be given to factors such as the maintenance of basic sanitation standards, programs for the application of insecticides, location of habitable areas away from potential mosquito production areas, and so forth. The following principles and practices for prevention and control of vector problems should be followed in the planning, design, construction, operation, and maintenance of water and related land resource projects.

2.1 Impoundments:
1) All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2) Prior to impoundage, the reservoir basin should be prepared as follows:
a. The normal summer fluctuation zone of the permanent pool should be selectively cleared except for isolated trees and sparse vegetation along abrupt shorelines which will be exposed to wave action.
b. Dense stands of timber rooted below the normal summer minimum pool level but extending above that level should be selectively cleared.
c. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage with fluctuation of water levels.
d. If the summer fluctuation zone of the permanent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas located within flight range of population groups or recreation areas through the use of measures such as deepening and/or filling. This would minimize the need for repetitious measures for controlling vegetation and mosquito production.

3) After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreation areas frequented by significant numbers of persons:
a. All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.
b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

4) Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoir. This will minimize the need for repetitious measures for controlling vegetation and mosquito production.

5) As a general principle, waterside recreation areas, particularly those which have facilities for overnight human occupancy, should be located along sections of the reservoir which have a low production potential for mosquitoes and other aquatic insects of public health importance.

6) Biological control measures such as maintaining populations of mosquito larva predators should be exercised as needed.

2.2 Recreational Areas:
1.) Proper storage, collection, and disposal of solid and all liquid wastes should be practiced in order to prevent and control flies, wasps, mosquitoes, other noxious insects, rats, wild rodents, and other small mammals.

2) All buildings should be rodent proofed at recreation areas.

3) Where pit privies are provided, they should be located, constructed, and maintained in compliance with Michigan's Act 273 - Privy Law and Regulations. Where possible such unsatisfactory facilities should be replaced with modern water carriage sewage disposal systems.

4) Brush and weeds along paths, trails, roadways, and other areas frequently used by visitors should be treated with herbicides or removed in order to reduce the likelihood of tick and chigger infestation. Insecticides should also be applied along paths or roadsides to control tick and chigger infestations but only in accordance with recommendations and requirements of the State Department of Agriculture. Containers including tree holes, tires, and similar receptacles should be filled or removed to eliminate breeding places for mosquitoes and biting gnats.

2.3 Waterfowl Refuges:

1) Whenever possible, waterfowl habitat developments should be constructed so as to minimize mosquito problems.

2) Waterfowl areas which are to be flooded during the mosquito season should be diked or otherwise prepared with steep shorelines to preclude shallow water areas favorable for mosquito production. Banks should not be made so steep as to impair stability.

3) Provision should be made for water level management in waterfowl areas which will minimize mosquito production. This recommendation is particularly applicable to shallow areas used to provide establishment of food producing vegetation.

2.4 Irrigation:

1) Project Conveyance and Distribution Systems

a. Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous soil where excessive leakage would result in waterlogged areas, seeps, and ponds.

b. Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to prevent ponding.

c. Borrow areas should be made self-draining to prevent the retention of ponded water.

d. Where possible, provision should be made to prevent idle turnouts and other hydraulic structures from retaining residual water.

e. Effective measures should be provided to prevent ponding of leakage from water control structures.

f. Every effort should be made to establish delivery schedules which will provide farmers with adequate but not excessive amounts of water at proper intervals to insure efficient irrigation of the crops concerned.

g. Where feasible pipe should be used rather than open channels.

h. Vegetation and debris which would retard normal flows should be periodically removed from conveyance channels, water control structures, and drains.

2) Project Drainage Systems

a. Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and nonirrigable lands affected by the distribution and use of irrigation water on the project.

b. Drainage ditches should be designed, constructed, and maintained so as to minimize ponding in the channels and to insure free flows at all times.

c. Provision should be made to prevent water from ponding behind spoil banks.

d. Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.

3) Irrigated Farms

a. The sponsoring agency and other organizations concerned with irrigation agriculture or mosquito control should encourage irrigation farmers to use the following irrigation and drainage practices which will prevent or minimize mosquito sources:

1) The farm supply system, drainage system, and field layouts should be properly fitted to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

2) All surface irrigated fields should be properly leveled or graded to provide for efficient water application and removal of excess water without ponding.

3) An adequate drainage system should be provided for removal of excess irrigation water from all portions of the farm.

4) Irrigation methods should be used which will provide optimum irrigation efficiencies.

5) Application of irrigation water should be limited to the amount required to fill the crop root zone plus water to cover unavoidable losses and excess water needed to prevent upward movement of salts.

2.5 Ponds

1) The pond basins should be cleared of trees, brush, and other dense vegetation prior to impoundage.
2) Ponds should be constructed with steep banks to discourage growth of vegetation. Banks should not be made so steep as to impair stability.
3) All dense vegetation should be removed periodically from shallow water areas.
4) A minimum depth of 2 feet should be maintained.

2.6 Channel Improvements and Drainage

1) Borrow areas resulting from construction of the project should be made self-draining.
2) Material excavated from channels should be disposed of in such a way that it will not cause ponding of water.
3) Adequate drains should be installed to prevent ponding of water on berms or behind spoil banks, levees, and dikes.
4) Drainage ditches should be designed, constructed, and maintained to concentrate low flows and reduce silt deposition and subsequent ponding, thereby insuring free flows at all times.
5) Underdrains, culverts, inlets, etc., should be placed on grade to prevent ponding.
6) Collection sumps should be constructed with steep side slopes, and any emergent vegetation should be removed periodically.
7) Sections of natural channels that are cut off or bypassed by new channels should be filled or provided with adequate drains.
8) Interior drainage facilities should be well maintained to avoid excessive ponding.
9) The use of biological control measures such as stocking with the *Gambusia affinis*, the mosquitofish or top minnow, should be used where feasible.

2.7 Waterways, Terraces, Floodways, Diversion Channels, and Drainage Ditches

1) Waterways, terraces, floodways, diversion channels, and drainage ditches should be designed, constructed, and maintained to prevent the retention of ponded water or the creation of ponded areas which would be suitable for mosquito production. Check Submerged Lands Division of the Department of Natural Resources for permits.
2) Biological control measures should be used where feasible.

2.8 Supplemental Chemical Control Measures

1) In situations where adequate vector control is not obtained through prevention and source reduction measures, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control. The use of such chemicals should be cleared with the Department of Agriculture and Health and closely regulated to prevent the possibility of water pollution resulting from such activity.

3. FIELD SURVEY AND EPIDEMIOLOGICAL SURVEILLANCE: In order to insure that good principles and practices are actually being implemented,

that vectors are being controlled, and that disease and nuisance are being prevented, arrangements should be made for routine field surveys and for epidemiological surveillance. The routine field surveys should include not only inspections for implementation of physical measures, but also inspections for the presence of adult and larval mosquitoes and other vectors. Regular information on vector populations or disease occurrence is essential in guiding control programs or instituting new programs to cope with existing vector problems as well as unforeseen or emergency situations.

SECTION VI IRRIGATION

1. GENERAL: Due to the low dilution flows available in the upper portions of the Grand River Basin and the high degree of treatment being required for the discharge of sewage effluents to the basin's streams, land disposal of treated sewage is being considered for use in the basin. Such disposal will only be initiated after careful appraisal by the Michigan Department of Public Health. If such disposal is practiced, a potential for conversion of the waste to crop products will undoubtedly be considered. The following discussion represents a presentation of the information regarding sewage irrigation available to the Bureau of Water Hygiene of the Public Health Service.

2. SEWAGE IRRIGATION AND DISEASE: The use of municipal sewage in irrigation has long been practiced. Sewage "farming" in the United States began in the late 19th Century in Wyoming, Colorado, California, Utah, and Montana. At the present time, extensive sewage farming is done in the arid Western States, primarily due to acute water shortages and to keep sewage effluents out of surface waters. To prevent disease transmission, the use of raw, settled or undisinfected sewage has been prohibited on vegetables grown for direct human consumption (produce) in most of the states.

Past experience with unrestricted sewage irrigation has demonstrated that disease outbreaks and worm infestations can be caused by contaminated vegetables and fruits. Today, health department restrictions, low levels of population infections, and symptomatic treatment have practically eliminated epidemiological evidence of the occurrence of disease or worm infections from food contaminated by irrigation practices in the United States. This does not mean, however, that no threat exists from this source.

3. CONTAMINATION OF FRUITS AND VEGETABLES: Fruits and vegetables growing in infected soil have been found to be contaminated with pathogenic bacteria. Bacteria, protozoan cysts, and helminth eggs adhere tenaciously to the surfaces of vegetables, are not removed by ordinary washing, and are protected from the external environment. Survival of pathogens is primarily dependent upon the type of pathogen and the presence of moisture. Survival of pathogens on vegetables has been shown to vary from a few days for amoeba cysts to as long as 30 days for *Ascaris* eggs. Disinfection of contaminated vegetables with detergents or chlorine compounds has been shown to be ineffective or unreliable.

4. PUBLIC HEALTH POLICY: The only reliable means for preventing exposure of the public to contaminated produce is prevention of such contamination from occurring. This has been achieved in the past by

health department regulations prohibiting the use of night soil and municipal sewage for the irrigation of produce. Improvements in sewage treatment practice and the application of secondary treatment on a wide scale have prompted efforts to obtain approval of the use of treated waters for unlimited irrigation. Health authorities are generally reluctant to accept such use due to the hazards associated with the source of the waters, the unknown factors of pathogen survival, and the inconsistency associated with many treatment plant operations. A conservative approach is, therefore, adopted which generally assures safe use of the subject water. This conservative approach is reflected in the recommended guidelines presented herein.

5. IRRIGATION WITH POLLUTED SURFACE WATERS: The restrictions applied to direct use of sewage for irrigation have not generally been applied to polluted surface waters used for irrigation. this is primarily due to the fact that few cases of disease or worm infestation have been associated with the use of polluted surface waters for irrigation. The lack of serious hazard associated with this use of polluted surface water is probably due to the fact that dilution, natural treatment processes, the hostile environment to most human pathogens normally associated with surface waters, and the time lapse between the pathogen's leaving its last host and harvesting of the irrigated produce practically eliminate the danger of infection occurring with ingestion of the irrigated produce.

For most cases in which the use of polluted surface waters for irrigation is questioned, the recommended criteria of the "Report of the Committee on Water Quality Criteria" published by the Department of Interior are considered adequate. These criteria state "The monthly arithmetic average density of the coliform group of bacteria shall not exceed 5000 per 100 milliliters and the monthly arithmetic average density of fecal coliform shall not exceed 1000 per 100 milliliters. Both of these limits shall be an average of at least two consecutive samples examined per month during the irrigation season and any one sample examined in any one month shall not exceed a coliform group density of more than 20,000 per 100 milliliters or a fecal coliform density of more than 4,000 per 100 milliliters".

For special cases, however, in which little dilution is available, environmental conditions are more than normally hospitable to pathogens, and/or time of exposure to hostile conditions is short, the local or State health departments should make an appropriate determination regarding the water quality to be used for irrigation.

6. MINIMUM RECOMMENDED GUIDELINES FOR USE OF EFFLUENT FOR IRRIGATION: The practice of irrigation of agricultural crops raises a number of health questions regarding water quality to be used and vector control. The factors relating to mosquito and other vector problems are primarily those of hydraulics and drainage. These factors are discussed under Section V, Vector Control, of this guideline. Recommended

water quality criteria for polluted stream waters used for irrigation are presented and adequately discussed in the "Report of the Committee on Water Quality Criteria" published by the Department of Interior.

The recommended guidelines presented below are considered to be minimum guidelines applicable to the direct use of sewage or treated sewage for irrigation. Local and state regulations regarding this usage should be adhered to within their respective jurisdictions.

Waste water utilization programs can play an important role in the irrigation of crops. Careful regulation of this practice is necessary to prevent the contamination of those food crops which are eaten uncooked and to prevent unnecessary exposure of the public to pathogen laden waters.

6.1 Definitions: The following terms shall have the meaning specified below:
"Effluent" - The treated sewage discharged from waste treatment facilities.

"Irrigation" - Watering of plant life by spraying and direct flow methods.

"Secondary Sewage Treatment Plant" - A sewage treatment plant based on biological treatment processes.

"Sewage" - All untreated liquid wastes containing suspended and dissolved material, human, animal, or vegetable matter as well as chemicals in solution.

"Spray Irrigation" - Irrigation by spraying or sprinkling.

6.2 Irrigation with sewage: Sewage should not be used for irrigation.

6.3 Irrigation with effluent:
1) The sewage to be used for irrigation should be treated by secondary sewage treatment and disinfection.
2) After being treated, the effluent should meet the bacteriological guideline of 100 coliform MPN per 100 ml or less in four out of five samples taken on a schedule specified by the state or local health agency having jurisdiction.

6.4 Precautions to be taken before irrigation: Before irrigation with effluent is carried out, the following precautions should be taken:
1. The areas to be irrigated should be clearly designated with signs warning in clear and visible letters that effluent irrigation is being carried out.
2. The pipe network for effluent irrigation should be completely disconnected from the regular water supply network.
3. All necessary steps should be taken to prevent mosquito or fly breeding in the area to be irrigated. (See Vector Control guideline, Section V.)

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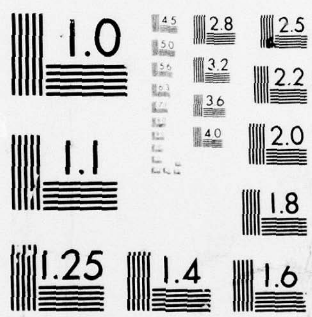

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4. All necessary steps should be taken to prevent the dissemination of odors which may reach residential areas, or other areas in which the public is likely to be present.

5. No spray irrigation with effluent should be carried out within a distance of 200 yards from a residential area or 50 yards from a road.

6. Ridge and furrow irrigation with effluent may be carried out if the distance to residential areas is greater than 100 yards and the distance to roads is greater than 25 yards.

6.5 Crop limitations for irrigation with effluent: Conditions under which irrigation with effluent may be permitted are:
1) Those crops normally eaten cooked or having an outer peel or husk which is normally removed and discarded.
2) Crops for industrial use and not used for human consumption.
3) Nursery trees.
4) Fodder crops for harvesting.
5) Fodder crops for grazing of cattle, sheep, swine, and poultry on condition that the animals do not graze on the irrigated area while the area is wet from the effluent application.

6.6 Irrigation of deciduous fruit trees with effluent: In spite of the conditions in paragraph 6.5 above, direct flow irrigation or low-level spray irrigation of deciduous fruit trees with effluent may be safely done if the following conditions are fulfilled:
1) The spray irrigation is executed so as to prevent effluent from coming in contact with fruit.
2) Spray irrigation ceases two weeks before fruit is harvested.
3) The fruit falling to the ground is not marketed.

6.7 Irrigation of lawns with effluent: Effluent should be used to irrigate lawns only where the lawns are closed to the public while the effluent is being applied and while the irrigated lawns remain wet from the effluent application.

SECTION VII RADIOLOGICAL HEALTH

1. SOURCES OF RADIOACTIVE CONTAMINANTS: The sources of radioactive water contamination are numerous and include hospitals, industrial laboratories, nuclear reactors, and full fabrication and reprocessing plants. Hospitals and certain industrial and research laboratories dispose of low levels of water-borne isotopes used in basic research and in treatment of patients by flushing to sanitary sewers. Radioactive wastes can also occur at these facilities through leakage from continuous processing systems. Considering the diversity of radiological medical and research applications, almost any isotope might occur in the liquid wastes of these facilities. The use of isotopes in medicine and research, however, is not normally great enough in any given area to present a hazard to individuals through contamination of the environment.

The principal types of reactors currently operating in the United States are electric power reactors, production reactors, and research reactors. Of these three types, power reactors will present the greatest problems of radioactive liquid waste disposal in the future due to the tremendous growth of the nuclear power field now expected. Projected data indicates that nuclear power will move from its position of supplying approximately 1% of the electrical energy requirements in 1969 to around 25% in 1980. Production and release of liquid wastes can be expected to increase proportionately with this increase in nuclear power generation.

The types of nuclear power plants presently being designed and operated in the United States are pressurized water reactors (PWR) and boiling water reactors (BWR). Both types of facilities have been designed to release relatively low levels of liquid wastes during normal operation.

2. SURVEILLANCE AND CONTROL OF RADIOACTIVE CONTAMINATION: The legal basis for the control of such contamination in Michigan is Act 146, P.A. 1919 as amended. Under this act the State's "Regulations governing use of radioactive isotopes, x-radiation and all other forms of ionizing radiation" were established. Surveillance is divided between the Michigan Department of Public Health and the Michigan Water Resources Commission. Within the Department of Public Health the Section of Occupational Health controls usage and disposal and the Division of Engineering monitors drinking water. The Water Resources Commission monitors discharges of radioisotopes into the State's waters. All potential sources of radioactive contamination must be registered with the Section of Occupational Health.

3. SOURCES OF RADIOACTIVE CONTAMINATION IN THE GRAND RIVER BASIN: Levels of contaminants coming from hospitals and industrial laboratories are known to be very low and are not considered to be problem sources

in the future. There are no nuclear power plants, fuel fabrication and reprocessing plants or nuclear burial or disposal sites in the Grand River Basin. In addition no such major potential sources of radioactive pollution are known to be proposed for future construction in the area. In view of the fact that no serious potential sources of radioactive contamination exist or are expected to exist in the Grand River Basin, no problems from this health aspect of water resources should occur.

Bibliography

For those desiring reference material, references keyed to the text of these Health Guidelines are available from:

Division of Engineering
Michigan Department of Public Health
3500 N. Logan Street
Lansing, Michigan 48914

or

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